

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

12

19.9
312

A Summary of Current Program 7/1/64
and Preliminary Report of Progress
for 7/1/63 to 6/30/64

-

ANIMAL HUSBANDRY RESEARCH DIVISION
of the
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
and related work of the
STATE AGRICULTURAL EXPERIMENT STATIONS

U. S. DEPT. OF AGRICULTURE
NATIONAL LIBRARY

NOV 12 1964

CURRENT SERIAL RECORDS

This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1963, and June 30, 1964. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Animal Husbandry Research Division, Agricultural Research Service, U. S. Department of Agriculture, Washington, D.C.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

July 1, 1964

TABLE OF CONTENTS

	Page
Introduction.....	ii
Area No. 1: Animal Biology.....	1
Area No. 2: Beef Cattle -- Breeding.....	21
Area No. 3: Beef Cattle -- Physiology.....	35
Area No. 4: Beef Cattle -- Nutrition and Management.....	40
Area No. 5: Dairy Cattle -- Breeding.....	51
Area No. 6: Dairy Cattle -- Physiology.....	67
Area No. 7: Dairy Cattle -- Nutrition and Management.....	78
Area No. 8: Poultry -- Breeding.....	95
Area No. 9: Poultry -- Physiology.....	104
Area No. 10: Poultry -- Nutrition.....	111
Area No. 11: Poultry -- Improvement of Viability.....	117
Area No. 12: Poultry -- Broiler Losses.....	124
Area No. 13: Sheep and Goats -- Breeding.....	127
Area No. 14: Sheep and Goats -- Physiology.....	134
Area No. 15: Sheep and Goats -- Nutrition and Management.....	140
Area No. 16: Swine -- Breeding.....	147
Area No. 17: Swine -- Physiology.....	158
Area No. 18: Swine -- Nutrition and Management.....	162
Area No. 19: Fur Animal Husbandry.....	167
Area No. 20: Animal Performance and Management Records.....	177
Area No. 21: Production Influences on Animal Products.....	183
Line Project Check List.....	199

INTRODUCTION

Research in livestock production will benefit the public through lower-cost animal foods and an assured supply of high quality foods more suited to their needs. It assists individual farmers by lowering costs and increasing net income. It will also improve the utilization of the surplus grain supply. More efficient high producing animals of the various classes will aid the small farmer particularly, permitting a more diversified enterprise. They will strengthen rural area development programs by making livestock farming on a small-scale more attractive.

The mission of the Animal Husbandry Research Division is to conduct research which will reduce costs of animal production, provide the consumer with animal products of improved quality, and provide basic animal science information. As more of the simpler practical problems of animal production are solved, more complex problems must be attacked. For solving these complex problems basic information on the genetics, physiology, and nutrition of livestock is necessary. Even though such basic information is obtained in the Animal Husbandry Research Division by the majority of our scientists, increasing emphasis is placed upon basic research and studying problems in depth.

The investigations of the Animal Husbandry Research Division are carried out by a staff of approximately 500 persons, of whom about 160 are professional research scientists. The work is conducted at Beltsville and at field locations throughout the United States. Many of the projects are carried out cooperatively with State agricultural experiment stations, and some with other Federal agencies, other divisions in the Agricultural Research Service, and non-federal organizations. Investigations are carried on in various aspects of genetics and breeding, nutrition and feeding, feed composition and evaluation, anatomy, physiology, and management. National cooperative record of performance programs are conducted with dairy cattle and poultry. Research also is conducted on the quality of meat, milk, and eggs, as influenced by production factors; on the basic metabolism in the animal body of pesticides, hormones, and other chemicals used in agricultural production and the effects of these chemicals on animal products; and on the control of avian leukosis in poultry.

It is frequently costly and unwise to make extensive program shifts until a promising and worthwhile research project is completed. Furthermore, most animal husbandry investigations are necessarily long term in nature. Consequently, it is easy to lose sight of the degree to which progress has been made in a yearly published report such as this. A few of the more recent developments which have made marked contributions to the industry and/or to their research activities are mentioned briefly below.

Removal of the bursa gland reduces leukosis in chickens. Research at the Regional Poultry Research Laboratory at East Lansing, Michigan, and cooperators indicates that the surgical removal of the bursa gland (bursa of Fabricius), in most cases, prevented them from contracting visceral lymphomatosis. This was also the case when both the bursa and thymus gland were removed but removal of only the thymus gland had no detectable effect on the incidence of the disease. Surgery was performed on young chickens to remove the bursa, the thymus, or both. Neither gland was removed from a group of chicks maintained as controls. All were inoculated with a cultured RPL 12 leukosis virus, some before surgery and some after. The growth and development was not affected by the surgery. Bursa removal was effective whether the operation was at 2 or 29 days of age and whether the chickens were infected at 1 day or 28 days of age. Even when the virus was administered to day-old chicks and the operation was performed 4 weeks later, bursectomy drastically reduced the incidence of visceral lymphomatosis. This is particularly significant because the RPL virus multiplies in chickens to such an extent that much virus can be found in saliva and droppings by 4 weeks of age. Of considerable interest was the failure of either or both thymectomy and bursectomy to influence the incidence of other forms of leukosis--erythroblastosis or osteopetrosis. Previous research has shown that RPL 12 virus takes different forms in chickens, depending on virus dosage and age of infected chicken.

Crossbreeding increases lamb production. Birth weights, weaning weights, and gain from birth to weaning were generally higher for crossbred than for purebred matings at Beltsville. Crosses of Hampshire, Shropshire, Southdown, and Merino sheep showed increases over purebreds of 7 lbs. for weaning weight. Pounds of lamb weaned per ewe bred, obtained by combining reproductive rates with weaning weights, were 6 lbs. greater for 2-breed crosses than for purebreds. Three-breed crosses exceeded 2-breed crosses by 12 lbs. and 4-breed crosses exceeded 3-breed crosses by 8 lbs. Thus, crossbreeding led to large increases in pounds of lamb produced per ewe.

Zinc in the diet of the sow protects pigs from parakeratosis. Studies at Beltsville, Maryland, of zinc in colostrum and milk from sows indicated that the level of zinc in the diet of the sow may markedly influence the susceptibility of pigs to parakeratosis. Supplementation of ordinary sow diets during gestation and lactation did not increase the level of zinc in the colostrum but did hold the level of zinc in milk much above that from unsupplemented sows at 35 days lactation. Attempts to experimentally produce parakeratosis in pigs from sows receiving supplemental zinc were unsuccessful, while this condition was readily produced in pigs from dams on unsupplemented diets.

Urinary calculi reduced by ammonium chloride. A practical application of previous research is the increased use by both ranchers and feedlot operators of ammonium chloride as a control measure in the prevention of urinary calculi. It is now in use in several western and southwestern States.

Within recent months there has been a large increase in requests for information from individuals and feed manufacturers for details on the use of ammonium chloride in feeds and feed additive mixtures. This is a good example of basic information being applied to beef cattle production in a relatively short time.

Importance of dairy type. Although many studies have reported that the relationship between dairy type and milk production is low, breeders still have placed great emphasis on type because they thought it contributed to length of productive life. Beltsville workers have shown, however, that most dairy cows leave herds for reasons not related to present standards of dairy type. These reasons were largely environmental. Therefore, efforts to improve length of life or production through selection for high dairy type scores are ineffective. The main value of high type scores is related to the sale value of the animals among registered breeders.

These findings are being accepted and used widely by dairy extension workers, A.I. personnel, and farmer breeders. Reduced emphasis on type as a criterion for selection of dairy cattle will allow increased emphasis on selection for the more important economic traits, especially milk yield.

Water starvation in poults. Research at Beltsville has shown that extremely high mortality in young turkey poults may result from rapidly drinking large amounts of water following water deprivation periods. Mortalities of 60 to 100% were obtained when two-week-old poults were deprived of water for approximately 48 hours. Attempts to return water-starved poults gradually to full water were unsuccessful. These results indicate that early mortality in poults may be due, in some cases, to water starvation instead of pathogens and emphasize the need for supplying drinking water to young poults at all times.

Byproducts with thyroid material must not be fed to mink during reproductive season. Feeding of "gullet trimmings," a packing house byproduct, to female mink in the spring caused reproductive failures due to resorption of the kits and poor milk production by the mothers. Levels of 7-1/2% and 15% of gullet trimmings or their equivalent as Tri-iodothyronine and sodium L-thyroxine gave poor reproductive performance. Levels below 7-1/2% were not evaluated.

Heterosis found in crosses of beef breeds. Systematic study of straightbred animals of the Angus, Hereford, and Shorthorn beef breeds as compared to all possible crosses among them indicate heterosis in pre- and post-natal calf survival rates and in weaning weight of individual calves large enough that pounds of calf weaned per cow bred is at least 10% greater in crossbred as compared to straightbred matings. Heterosis of a lower order of magnitude is found in postweaning growth but not in carcass characters. Preliminary results suggest rather important heterotic effects on brood cow performance. These results may have important implications for commercial beef production in the United States.

AREA NO. 1: ANIMAL BIOLOGY

Problem. The extent of applicable results in animal husbandry research is severely limited by a paucity of basic information on the genetics, nutrition, and physiology of our livestock. The basic research in progress has resulted primarily in revealing the inadequacy of our information regarding the functional processes within the animals we are trying to control and develop for human use. Basic research is required in such fields as animal cell metabolism and reproduction, enzymology, physiological bases for heredity, and microbiology of the rumen and intestines. Results of such studies provide the basis for additional research applied to the husbandry of each type of livestock.

USDA AND COOPERATIVE PROGRAM

This area consists of basic research conducted by geneticists, biochemists, physiologists, and nutritionists. It includes studies in the Pioneering Laboratories on somatic variations of red cell antigens, on the nature of the specificity of antigens and antibodies, and on methods and theories of population genetics. Research in reproductive physiology is in progress to determine the biochemical composition and the defensive mechanisms of the uterus. Still other physiological investigations are involved with the response of mammary tissue to invasion by infectious agents. One study of long standing has the primary objective of describing, fully and in detail, the gross and microscopic anatomy of the domesticated fowl. Research on the metabolic role of vitamin B₁₂, the investigation of unidentified nutrients in food and feed, and biological and chemical studies of rumen metabolism are also being undertaken. Investigations are in progress on the development of counter measures to prevent contamination of animal products by fallout from nuclear explosions. The work is conducted at Beltsville, Maryland; East Lansing, Michigan; and in cooperation with the Indiana, Iowa, Maryland, Michigan, Minnesota, New York, Utah, and Wisconsin Agricultural Experiment Stations.

The Federal scientific effort devoted to research in this area totals 22.7 professional man-years. Of these, 5.9 professional man-years are in genetics, 10.9 in physiology, 2.0 in nutrition, 2.6 in rumen function, 1.0 in radioactive fallout, and 0.3 in program leadership.

There are 8 grants involving Public Law 480 funds in foreign countries financing research related to animal biology. Two are with the National and University Institute of Agriculture, Rehovot, Israel, and provide for (1) studies on the separation of young and old spermatozoa and (2) investigation of factors affecting long-term storage of sperm. They are supported for 3 years (1963-1966) with a total of \$86,904 equivalent in Israeli pounds.

There are 3 PL 480 projects in Poland. One is on the secretion of anterior pituitary hormones and ovulation in small ruminants. It is supported for 5 years (1960-1965) by \$52,455 equivalent in Polish zlotys at the Polish Academy of Sciences, Jablonna. A 4-year project (1962-1966) at the College of Agriculture, Poznan, is concerned with protein compounds of vitamin B₁₂ and its analogs. It is supported with \$38,138 equivalent in Polish zlotys. Another project is at the Polish Academy of Sciences, Warsaw. It involves the determination of the metabolic pathway of protein biosynthesis in the liver and has a 5-year duration with support amounting to \$60,411 equivalent in Polish zlotys.

A project entitled, "Study of metabolism of zinc in living organisms by means of zinc 65," is in progress at the Institut Espanol de Fisiologia y Bioguimica, Madrid, Spain. It has a duration of 4 years (1961-1965) and is supported by \$35,277 equivalent in Spanish pesetas.

The University of Montevideo, Uruguay, is conducting a project of 5 years' duration on the nutritional value of fish silage. It has \$112,785 equivalent in Uruguayan pesos of support.

A project was initiated with the Hebrew University, Jerusalem, Israel, on the effect of X-rays on viability genes with special reference to their action in heterozygotes and to the mechanism of heterosis. The project duration is 4 years and has support of \$34,650 equivalent in Israeli pounds.

PROGRAM OF STATE EXPERIMENT STATIONS

Genetic research with several laboratory species range from evaluation of theoretical selection and mating systems which might have application in the improvement of economic species, to the study of DNA chemistry in the duplication and transfer of genetic information at the cellular level. Genetic changes produced in blood antigens and serum proteins are proving to be very useful areas for basic investigations. Several anatomical conditions of genetic origin in economic species are being studied both to determine means of controlling them and to determine the biochemical processes directly responsible for the deviations.

Physiological conditions associated with the female animal in the onset of puberty, estrus, pregnancy, and lactation are being studied with primary emphasis on the levels of and interaction of the several hormones. Many of these studies require detailed chemical and histological determinations. Detailed efforts are also required with semen including production, evaluation, and preservation. One such study includes comparison of mature and immature spermatozoa and somatic cells with respect to nucleic acids and lipoprotein-carbohydrate complexes. Eleven States in the western region and the U. S. Department of Agriculture are cooperating in regional project W-46, "The Effects of Environmental Stresses on Range Cattle and Sheep Production."

The fundamental biochemical and physiological factors concerned in genetically variable growth and the significance of various parts of the alimentary tract in the transfer of minerals are also being studied.

Nutrition investigations include the requirements and interrelationships among various nutrients (both macro- and micro-); the influence of factors such as vitamins, hormones, and antibiotics on growth and tissue composition; nutritional factors in certain toxicity problems such as high molybdenum and high selenium; the effect of climate, soil, physical form, and curing method on nutritive value of forages; and the metabolism of fission products. There are several cooperative regional projects (NC-63, NE-24, S-45, and W-34) that are considering various factors affecting the nutritive requirements of livestock and the nutritive value of forages. The fundamental physical and chemical factors responsible for the development of the functioning rumen and the basic factors influencing fermentation of feedstuffs in the rumen are receiving major attention. The cooperative regional project NC-27 with the States of the north-central region and the U. S. Department of Agriculture cooperating is making significant progress in determining the plant and animal factors concerned in bloat.

The State stations have 152.4 professional man-years devoted to this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics

1. Methods and theories of population genetics. (AH p-2)

(a) Research on mice. Studies have been continued on the long-term selected populations of mice which were started by Dr. H. D. Goodale in 1931. Analyses of data from the first 85 pedigreed generations of the Goodale Large Whites showed that the population reached a plateau after approximately 35 generations of selection for large body weight. Thereafter, continued selection was ineffective in increasing the mean body weight despite the indicated presence of additive genetic variance.

During the long period of plateau, heritability estimates obtained from the sire component of variance, regression of offspring on sire, and regression of offspring on dam remained positive and appreciable in size except in one ten-generation period. From analyses by ten-generation periods or decades, the unweighted averages of the three types of heritability estimates were .21, .03, and .24 for the fourth, fifth, and sixth decades, respectively. Realized heritabilities for the same decades were .02, -.06, and .09.

It is known that primary emphasis in selection was shifted from body weight to litter size in the latter part of the fourth decade and reversed in the latter part of the fifth decade. Part of the effect is shown in the averages of the realized selection differentials which were 4.23, 2.88, and

5.50 grams in the fourth, fifth, and sixth decades, respectively.

From the above results, it is clear in this experiment that intense selection has tended to cause over-estimation of the proportion of variance which is additively genetic. The bias largely disappeared when selection emphasis was shifted to another trait (litter size) but re-appeared when emphasis was returned to the original trait (body weight). In the decade following the shift, litter size appeared to increase and a slight increase in additive genetic variance for body weight may have occurred. If the heritability estimates for body weight during the plateau are over-estimates, then the probable cause of the plateau is the exhaustion or near-exhaustion of additive genetic variance. Other evidence indicates that at least some non-additive genetic variance remains in the population.

The effect of sterility on selection differentials has been removed by using realized selection differentials. However, sterility could also affect the rate of gene loss and the size attainable at selection limits. At least the direct action of sterility on reproduction did not cause the plateau because adequate numbers of offspring were produced by the fertile mice.

The second Goodale population initiated in 1931 is selected for percentage of white hair. Foundation animals consisted of one male with a few white hairs on the forehead and four self-colored females. The average percentage of white hair per individual in the population now exceeds 70 and a total of 19 all-white, dark-eyed individuals have been produced in recent generations. Only three of the all-whites were females. Selection progress results whenever positive selection differentials are obtained. However, realized selection differentials for females are usually negative because of a high rate of sterility in females having high percentages of white. Also, the sex ratio is high as are pre- and post-weaning mortality.

Tests of all-white males mated to females from an unrelated strain show that all genes for white are recessive to the wild-type genes for color. In addition, evidence is accumulating which indicates that the appearance of white spots is dependent on epistasis. Offspring of crosses between all-white males and color female descendants of the foundation stock show less than 1% white in the F_1 and less than 10% white in the F_2 generation with an extremely skewed distribution.

Results from these experiments have important implications for large animal breeding experiments and practices involving selection for quantitative traits. Information on the nature of selection plateaus and limits, the type of gene action, the role of relaxed selection, and the effects of selection on reproduction are valuable aids in this field.

(b) Research on Tribolium (a flour beetle). Additional information has been obtained on the effect of mating systems and selection on an additive trait (pupa weight).

The average slope of the mass selected, assortatively mated lines was significantly steeper than the mass selected, randomly mated lines. Though significant, this difference was quite small and seems to conform to theoretical expectations.

In the mass selected lines, estimates of phenotypic and genetic variance declined regardless of mating systems. There was a tendency for phenotypic variances to decrease in the randomly selected lines, but this was not the case for estimates of genetic variance.

2. Basic research on blood antigens and antibodies. (AH p-1)

(a) The nature of antigenic specificity. Studies of the "Hi" substance have been continued. At the outset of these experiments, it was found possible to inhibit the agglutination reaction between the red cell and Pisum arvense extract, the agglutinin. This discovery permitted studies to be made on the nature of the "Hi" substance and on the bonding between the agglutinin and the agglutininogen.

Monosaccharides inhibit when the third and fourth hydroxyls of these hexoses are in the trans position with the third hydroxyl in the up and fourth hydroxyl in the down position (Haworth symbolism). D-mannose and D-glucose possess these properties and inhibit the agglutination reaction. Tests were made of glucose or mannose derivatives in which there were substitutions for the hydroxyls at each of the positions along the chain. These tests permitted a determination of the hydroxyls which were of importance in the linkage between the agglutininogen and the agglutinin. A number of derivatives for each of the positions enabled exclusion of the first, second, third, and fifth hydroxyls. Evidence that the fourth and sixth hydroxyls were involved in the linkage was obtained from a variety of sources. Direct test of a number of compounds substituting only for the fourth and only for the sixth implicated these hydroxyls. Confirmation came from tests involving the use of pentoses which lack a sixth hydroxyl, from tetra and penta-acetates which substitute for the fourth as well as other hydroxyls and from tests of oligosaccharides. In the latter tests, comparisons were made between expectation and observation based on the inhibition expected from oligosaccharides possessing sugars with the third and fourth hydroxyls in trans configuration with unlinked fourth and sixth hydroxyls and alpha linkage between residues. Oligosaccharides with sugars lacking these properties would have decreased inhibition; those possessing more than one residue with these properties would have a greater inhibition than the standard. Agreement between observation and expectation was excellent and fully confirmed the importance of the fourth and sixth hydroxyls in the linkage between agglutinin and agglutininogen.

(b) The detection and preparative separation of hemagglutinating antibodies following starch gel zone electrophoresis. The high degree of analytical resolution afforded by electrophoresis on starch gels is in marked contrast to the difficulty of using this procedure for preparative separation. While it has been possible to recover some proteins, nucleic acids and other substances from gels, detection and recovery of many specific antibody proteins have often proven elusive.

A procedure for the recovery of human anti-A agglutinins following zone electrophoresis was developed.

Significant titers of antibody containing liquid were obtained from the gel by cubing of selected sections into one millimeter pieces and allowing these to stand in the cold. Additions of small volumes of suitable solutions assisted in diluting and carrying the extruded antibody from the gel surface. A recovery of 73% of crude immune anti-A serum was obtained from the gel. Somewhat lower recoveries were attained for crude P. lunatus extract (41%), for partially purified immune anti-A serum (58%), and for partially purified P. lunatus (30%).

A method for the detection and localization of antibody by direct incubation of one millimeter sections of gel with A₁ cells was also developed.

(c) Somatic variation of red cell antigens. Studies of somatic variations of red cell antigens in pigeons with respect to the effect of X-irradiation on the frequency of "A" inagglutinable cells was continued. In the first of a series of experiments, birds heterogeneous with respect to agglutinin titer, sex, age, and breed were split into five groups and given different X-ray doses. The inagglutinable frequency was determined just prior to irradiation and at two and four months following irradiation. With 62 r the two-month response was a slight decrease (-1.87) while at four months an increase of 4.73 fold over the base level, the control birds of which remained unchanged for the entire period of test. With 360 r at two months there was a 9.16 fold increase and at four months a 7.14 fold increase. With higher doses there were decreases at two months and subsequent increases at four months which confirm a similar previous observation. The 662 r treated group at two months was +0.04, at four months +8.41; 964 r at two months was -32.53, at four months -4.50; 1265 r at two months was -3.52, at four months was +0.36. The initial decreases and subsequent rise in the inagglutinable frequency have been observed previously and suggest the operation of a selection mechanism.

An experiment was carried out which indicates that there is both a dose component as well as individual variation to contend with in the response of the pigeons to irradiation. In a group of the same age, sex, breed, and agglutinin titer, there was still variation in response to a single dose of 360 r. Two birds responded showing a 2.5 fold increase over the base level,

the control birds of this series remained unchanged (-.22); three other birds failed to respond at two months and were given a second dose of 360 r. They showed a -2.3 fold change in the number of inagglutinables at two months, a -4 fold decrease at four months, and at six months the inagglutinable frequency had risen to the base level. This provides a similar indication of the operation of a selective mechanism as was indicated in the high dose experiments.

Experiments to determine the sources of variability in response to irradiation are being carried out. Females of the same age, breed, and titer were given 360 r. The two month response was a 2.4 fold increase as compared with an average response of 1.15 for the males. The four month response for the females has not been obtained as yet but was 4.45 for the males.

(d) Antibody specificity. Studies have been continued on the general problem of antibody specificity. This laboratory has shown that agglutinins can be absorbed specifically with red blood cell stroma and distinct antibody fractions obtained by differential thermal elutions. The assumption that different dissociation energies are required to disrupt an antigen-antibody complex imply differences in the chemical constitution or physical size of antibodies have led to further studies of the physical properties of these fractions.

Incorporation of I-131 radioactivity into minute amounts of protein has been successfully carried out by modifying the McFarlane I-131-Cl technique. Loss of agglutinin activity has been negligible and a preparation is obtained with high I-131 specific activity. Use of labeled protein has been necessary because small quantities of purified antibody were obtained in elution experiments and labeling serves as a sensitive technique for protein detection. Labeled eluates have been further separated by starch gel electrophoresis and whereas protein detection by the usual staining methods using acid precipitated amido-black 10-B are negative, protein concentration curves have been constructed by the use of radioactive tracer counts.

Non-immune anti-B agglutinin has been partially purified by DEAE and CM-cellulose column chromatography. Elutions were carried out with increasing NaCl gradients buffered at pH 7.3 with phosphate. Although this is a rapid method for bulk separation of large amounts of material with high specific activity, only 10% of the agglutinin is recovered throughout the operation which also involves ultrafiltration reduction of fraction volumes. The anti-B antibody is restricted to a small area of the chromatograms. Immune anti-A sera when treated similarly show antibody distribution throughout the chromatogram. Active fractions obtained from various portions of the chromatograph show migration differences when isolated on starch gel electrophoresis.

Thermal eluates of immune anti-A absorbed and eluted from A₂ red blood cell stroma have been separated further by starch gel electrophoresis. Detection and localization of antibody activity were determined on 1 mm slices of gel. When crude sera is electrophoresed on starch gel 3 major groupings of antibodies were obtained; a portion which migrates towards the cathode, one which remains in the sample entry, and another group which migrates to the anode. Eluates obtained from low temperature elutions (37° C) have a larger ratio of antibodies which migrate to the cathode whereas high temperature eluates (56° C) contain a larger proportion of antibodies migrating to the anode. That this is related to charge or molecular size differences is shown in an experiment in which antibodies migrating 2.0 cm anodically when rerun appear at the same position on the starch gel. This can be demonstrated also for all other starch gel components which were reelectrophoresed.

Density gradient ultracentrifugation studies were conducted to determine whether thermally eluted fractions were related to molecular weight differences. A preformed linear gradient of sucrose can be made by employing principles suggested by Oster and Yamamoto. Serologically active protein in human immune anti-A sera was found to be distributed within a 20 to 38% sucrose gradient area indicating a broad spectrum of molecular weight heterogeneity.

Similar results were obtained using CsCl gradients although a salting out effect resulting in some precipitation of protein occurred during centrifugation. Partially purified sera using butanol to remove phospholipids and salt fractionation to exclude albumin have also been used and the same distribution pattern of active material was observed. Three aliquots of the serologically active protein depicted as heavy, middle, and light fractions were each rerun under the same conditions and it was found that each fraction segregated to the same density area from which it had been taken, demonstrating that these fractions differ in molecular size. The recovery of serological activity in the light fraction approximated 100% whereas in the heavy fraction which is more easily denatured less than 25% was recovered. Experiments are in progress to exploit these physical property differences and correlate them with those fractions obtained by thermal elutions.

B. Physiology

1. Avian anatomy. Our report last year outlined the objectives and scope of the project in avian anatomy. The external parts of the body, skin, feather, comb, beak, and oil gland, constitute the subject matter of the first volume of the series. The chapter titles are as follows:
(1) Origin of Birds and Breeds of Fowl and Laboratory Species; (2) Terms of Orientation - Topographic Anatomy; (3) Principles of Pterylosis;
(4) Pterylosis and Feather Coat of Domesticated Species; (5) Plumage Development and Molts; (6) Structure of Feathers - General Principles;
(7) Feather Structure in Domesticated Species; (8) Histology of Skin and

Feather Follicle; (9) Feather Muscles and Terminal Nerves and Vessels; (10) Dermal Blood Vessels; (11) Derivatives of Integument, Gross and Microscopic; and (12) Technics Used in These Studies.

It is estimated that the book will be between 400 and 500 pages in length and will contain about 300 illustrations, nearly all of which are original drawings; about a hundred of these were completed this past year; the others had been completed in past years. It is emphasized that the contents of the book represent new research and new data. It includes also new evaluations of work done in the past by others. We anticipate our work will establish uniformity of terminology in the literature of the future. It is expected that the text and illustrations will serve the needs of many disciplines of the poultry and veterinary sciences. Much of the writing has been on eight of the twelve chapters. Digressions have been made to study some parts of the skeletal, nervous, vascular and muscular systems, and subject matter of later volumes, in order to understand the organization of the skin. Included with this report is an example of an illustration completed this past year showing the arteries and veins in the skin of the chicken. This type of subject matter had not been worked out previously for any species of bird. The information contained in the illustration along with the names and description in the text should serve the needs of those interested in skin pathology or physiology for many years to come.

A chapter on Avian Anatomy for the volume by Biester and Schwarte, "Diseases of Poultry," has been completed and sent to the editors. This will be about 50 printed pages with 19 original illustrations covering the 10 organ systems of the body. Some 322 references to older classical literature as well as recent papers are mentioned. This should be valuable to the pathologist who sees practically none of this material in his journals. (AH e6-26)

2. Physiological and biochemical characterization of uterine tissue

(a) Quantitative characterization of uterine vascular permeability changes with estrogen. The uterine water and electrolyte changes occurring after estrogen administration have been thought to be due to an alteration in the permeability of the capillary membranes. During the past year these capillary permeability changes were followed by quantitatively measuring the amount of trypan blue dye bound by the uterine tissue. H_2O , ion, and trypan blue concentrations increased in response to estrogen. The trypan blue changes qualitatively paralleled water alterations but were quantitatively different. Histological examination to localize the site of the dye uptake demonstrated that the dye was extravascular and diffusely spread throughout the endometrium. This suggested that changes in capillary permeability, rather than the size of the vascular pool, appeared to be responsible for the trypan blue uptake in the estrogen-stimulated rat uterus. The results indicate that the water and electrolyte changes induced by estrogen are related to capillary permeability alterations. (AH h5-8)



Distribution of arteries and veins in lateral skin of chicken. The circles mark the points of emergence of cutaneous vessels from deeper vessels. This illustration will be printed in color, arteries in red, veins in blue.

(b) Role of histamine in the mechanism of estrogen action in the rat uterus. Histamine has recently been proposed as being the mediator of estrogen action in the uterus, and studies were initiated to determine whether histamine could reproduce the permeability and chemical changes that estrogens produce during the early time periods after administration. At 2 and at 4 hours after intraluminal injection of histalog (a non-active histamine analogue), NaCl control solutions or histamine, the uterine changes observed were similar to those elicited by estrogen. Since the results indicated that histamine was no more effective than osmotic control solutions, and since previous results had demonstrated that histamine could not reproduce the later, 24-hour effects of estrogen, our research did not support a specific role for histamine as the mediator of estrogen action. (AH h5-8)

(c) Kinetics of in vivo glycogen synthesis in the rat uterus. Characterization of in vivo glycogen synthesis in the rat uterus after estrogen administration revealed: (a) an initial lag phase of less than 2 hours; (b) a period, from 2-10 hours, when glycogen concentrations increased at a constant rate; (c) an equilibrium or steady-state period from 10-24 hours, followed by; (d) a decline in glycogen concentration approximately 24 hours after estrogen administration. Glycogen synthesis during the 2-10 hour period adhered to first order reaction rate kinetics. The rate constant (K) was $1.94 \times 10^{-3} \text{ min}^{-1}$, which resulted in an increase in glycogen synthesis of about 12% each hour. (AH h5-8)

(d) Effects of anesthetics and stimulators upon glycogen metabolism in the rat uterus. The mechanism of estrogen action in glycogen synthesis was further explored by studying the activating effect of epinephrine upon phosphorylase, the enzyme responsible for endogenous glycogen breakdown. Epinephrine was found to cause a 70% loss of uterine glycogen and a similar decrease in liver and muscle glycogen. This decrease could be prevented by the simultaneous administration of sodium pentobarbital. The tranquilizing drug, reserpine, was not able to prevent the epinephrine-induced glycogen breakdown. Ether anesthesia and reserpine were able to counteract some of the effects of estrogen in stimulating a uterine water increase and an elevated glycogen content. (AH h5-8)

3. Endocrine control of uterine defense mechanisms

(a) Histochemistry of mucopolysaccharides in rabbit uteri. Rabbits were treated with either estradiol, progesterone, or both and the presence of mucopolysaccharides studied. Mucopolysaccharides were present in larger amounts in the endometrial stroma of estrogen-treated than in progesterone-injected rabbits. The stainable material was digested by hyaluronidase, but trypsin did not affect its stainability. The staining reactions indicate that ovarian hormones control the presence and amount of certain free anionic groups in the endometrium. The mucopolysaccharides do not appear to be linked to proteins because there was no increase in stainability after trypsin treatment. (AH h5-8)

(b) Effect of glucocorticoids on inflammation in rabbit uteri. Since adrenal glucocorticoids inhibit acute cellular and vascular responses to inflammatory stimuli in some instances, their effect on inflammation in the rabbit uterus was studied. Glucocorticoids stimulated rather than inhibited the leukocytic response, and the corticoids had no apparent inhibitory effect on the increase in vascular porosity. The results fail to indicate that glucocorticoids inhibit acute inflammatory responses in the rabbit uterus. (AH h5-8)

(c) Effects of ovarian hormones and histamine on the vascular system of the sheep endometrium. Trypan blue and histamine were administered to ewes in various endocrine states to determine the permeability of the uterine vascular system. Ovarian hormones influenced the endometrial vascular system and the response to histamine was greater in ovariectomized than in estrous or luteal ewes, also indicating that the vascular response was modified by the hormones. (AH h5-8)

4. Growth and development of mammary gland tissue

(a) Placental influences in mammary gland growth. The role of the maternal placenta in mammary gland growth was determined by comparing whole amounts of rat mammary glands in the presence and absence of maternal placental tissue. A pregnancy group was compared with a group of pseudo-pregnant rats containing artificial maternal placentae (deciduomata) to provide all of the same hormonal conditions with the exception of embryos and fetal placenta. Pseudopregnancy represented a group in which only ovarian influences were present. Early mammary proliferation was about the same in mid-pregnancy as in corresponding times of pseudopregnancy or pseudopregnancy with deciduoma, suggesting that early growth was due primarily to the influence of ovarian hormones of non-placental origin. From day 13 to 21, however, pregnant rats continued to develop fully functional glands, while those of pseudopregnant rats, with no placental hormones, regressed to a condition showing only slight alveolar-lobular development. The presence of deciduoma prevented this regression and good mammary development was maintained at a level almost as high as in normally pregnant animals. (AH h5-1)

(b) Acute inflammatory responses of the ovine teat. The leukocytic response to inoculation with E. coli or S. aureus was determined in non-lactating estrous, luteal-phase and ovariectomized ewes. The E. coli elicited an intense leukocytic response by one-hour post-inoculation; the response to S. aureus was slightly slower. During the acute inflammatory response polymorphonuclear neutrophils infiltrated the teat cistern in large numbers. There was no apparent effect of endocrine state on the intensity or sites of leukocytic response. (AH h5-1)

5. Secretion of anterior pituitary hormones and ovulation in small ruminants. Previous studies had indicated that the neural pathway between

the hypothalamus and the pituitary was extremely important for mammary gland development as well as for normal function of the ovaries and uterus. Neurosecretory substances responsible for the release of pituitary gonadotropins were extracted from various parts of the hypothalamus and tested for their activity. These extracts were injected into the pituitary of rabbits and sheep and caused ovulation. Other extracts were incubated with pituitary slices in vitro and caused an increase in the amount of gonadotrophins released into the medium. (E 21-AH-1)

C. Nutrition

1. B₁₂ synthesis in the rumen. Cobalt deficiency in ruminants had long been known to have a marked deleterious effect upon feed intake. Later developments showed that the role of this element, and at present its only known role, in nutrition is as a constituent of the vitamin B₁₂ molecule. The cow obtains its supply of vitamin B₁₂ primarily through synthesis by the microflora of the rumen.

Two experiments measuring variations in the rumen synthesis of vitamin B₁₂ and its analogs due to differences in the ration of the cow have been conducted. In the first experiment, samples of rumen contents were obtained from cows fed one of four diets -- (1) chopped hay, (2) finely ground pelleted hay, (3) a hay and grain mixture, and (4) silage. In the second experiment, the cows were fed silage or hay, either ad libitum or restricted to maintenance level.

The comparative total vitamin B₁₂ activities of the rumen contents of cows fed silage were 1.7 to 4.4 times those of the rumen contents of cows fed the other rations, no matter whether the comparisons are made on a "wet" or dry matter basis and regardless of which method of assay is used as the criterion. The rumen contents of cows fed the hay-grain mixture contained the least vitamin B₁₂, while those of cows fed chopped hay or pellets gave intermediate values with little if any real difference between the two. Samples collected at 2-1/2 hours after feeding were more potent than those collected one hour after feeding, while those collected at 5-1/2 hours or 10 hours after feeding were still more potent. With the cows fed silage, there appeared to be a further increase between 5-1/2 and 10 hours after feeding. When compared on the "wet" basis, the dorsal rumen contained a markedly higher vitamin B₁₂ concentration than did the ventral rumen or the reticulum. On the dry matter basis, however, the samples from the reticulum averaged slightly higher in vitamin B₁₂ potency than those from the ventral part of the rumen, which in turn contained a slightly higher concentration than those from the dorsal region. There was some variation between collection periods, though it was not clear whether this was due to an effect of period as such or the result of differences in the cows used for the different rations during a particular period.

Results obtained by three different assay methods used generally paralleled each other, though suggesting somewhat different proportions of the various B₁₂ analogs in the rumen contents of the silage-fed cows.

Analyses of samples of the dietary constituents indicated that it is highly unlikely that the vitamin B₁₂ or B₁₂ analog content of the dietary ingredients could have accounted for much of the activity of the rumen contents.

The samples obtained in the second experiment have not yet been completely analyzed. To the extent that the experiments are comparable, they appear on the basis of the preliminary analysis to confirm the results of the first experiment. There seems to be little or no difference between animals fed ad libitum and those restricted to maintenance feed.

Since bacterial counts, volatile fatty acids and ammonia were determined on the same samples, the results on B₁₂ will be correlated with other such data. (AH h4-3)

2. Unidentified nutrients. Studies have continued on still-unidentified nutrients in foods and feeds.

Most of the experiments conducted this year with thyroprotein-fed rats have involved comparisons among dried whole liver, fishmeal and haemoglobin in regard to their relative ability to increase the growth rate of such rats. Haemoglobin has been reported by other workers to be among the most active of the naturally occurring substances for the "liver residue antithyrototoxic factor." As a result of the current series of tests, it would appear that haemoglobin evokes about the same response as dried whole liver, but that fishmeal, or its residue after extraction with fat solvents, contains an additional factor not provided by either of these two other substances.

From the results of other tests designed to measure the amount of storage of unidentified growth factors in the livers of rats and their depletion when thyroprotein is fed, it appears that the strain put upon rats by feeding them thyroprotein, even though it decreases their growth rate drastically and brings them near death, has a variable and probably minor effect on the content of protective factors in their livers.

Tests with normal rats fed the non-thyroprotein rations indicates that a requirement can be established for a factor(s) required for maximum growth rate; this factor can be supplied by fishmeal and possibly to some extent by dried liver. It is not necessarily the same as the one found beneficial for hyperthyroid rats. To establish a requirement for the factor, a bacteriostatic agent must be included in the diet. Even then the necessity for the factor appears to last for only two to three weeks and can be eliminated by including a relatively high percentage of roughage in the ration. These results suggest a possible involvement of the intestinal flora. Whether the

response to the supplements is vitaminlike in nature or is due to some other effect of the combination of nutrients involved is not yet clear.

Other workers have reported that an unidentified growth-promoting factor for chicks occurs in milk products. This factor was observed in dried skim milk, in whey, and even in analyzed reagent grade lactose hydrate, although lactose per se was thought not to be the active agent. Preliminary results after three weeks of an experiment designed in an effort to disclose a requirement by the rat for the reported factor have yielded no indication of such a requirement. The test will be continued for a longer period to ascertain whether any indications of a requirement develop at a later stage of growth. (AH h4-1)

D. Rumen Function

This work primarily relates to studies on rumen microbiology and metabolism in cattle. It is largely basic in nature but is also pertinent to work on nutritional efficiency of cattle. (AH h2-3)

1. Methanogenic bacteria. The species Methanobacterium ruminantium, Smith and Hungate, was isolated and characterized last year. Nutritional studies were hampered by lack of methods to obtain good cell crops. In this year's work, adequate methods were developed. The organism was shown to grow very well from inoculum consisting of washed cells and using CO₂-H₂ gaseous phase and a cysteine - Na₂ S reducing system to maintain anaerobiosis. At least three groups of factors present in rumen fluid and not present or replaced by factors in yeast extracts and crude casein digests included in the complex assay medium have been recognized. Acetate is required in very large amounts; 2-methyl-n-butyric acid and possibly other 4 and 5 carbon volatile fatty acids are essential; and an as yet unidentified factor(s) present in the acid ether extract residue of rumen fluid is essential. The latter factor(s) occurs in two forms in rumen fluid and only one of these is essential for growth of the bacterium. The factor(s) is highly water soluble, dialyzable, not extractable with acid ether, and stable to heat and acid. Neither is a cation, but one appears to be an acid stronger than acetic acid while the other does not appear to contain an anion. Studies on this factor(s) are continuing. This is the first study showing an organic growth requirement for any methanogenic bacterium and suggests that much of the cell carbon of this organism is derived from exogenous volatile fatty acids and CO₂.

2. Studies on the nutrition of bacteroides ruminicola. Studies reported last year indicated that two strains of this species could be grown in simple chemically defined media containing cysteine, methionine, and ammonia as the sole available nitrogen sources. Ammonia was the main source of nitrogen and could not be replaced by mixtures of free amino acids or many other possible nitrogen sources. However, oxytocin, a peptide

containing nine amino acid residues, and unknown peptides obtained from tryptic digests of casein and containing about five or more amino acid residues were excellent sources of nitrogen. It has now been shown that a peptide similar to oxytocin, vasopressin, and tryptic digests of E. coli protein are also excellent nitrogen sources for the organism, but high molecular weight polymers of single amino acids are not utilized. Some of the results obtained on the two strains have been confirmed in studies of all available strains. All grew well with ammonia but none with free amino acids, as the main source of nitrogen. Most grew very well with peptides as the main nitrogen source.

Studies have been initiated to elucidate the mechanism of peptide utilization and to obtain information on the reasons behind the organism's inability to utilize mixtures of free amino acids. Studies using short-term incubations of the organism in the presence of very small amounts of free or peptide bound proline-C¹⁴ show that the organism will not take up free proline but will very rapidly take up proline-C¹⁴ peptides of intermediate length and, after a short lag will fix all of the C¹⁴ taken up into cell polymers, probably protein. These results suggest that the differences between free amino acid and peptide utilization by the species is based on differences in the ability of these compounds to penetrate the cell membrane. These studies, important to our understanding of protein metabolism in the rumen, are continuing.

3. Enumeration and isolation of rumen bacteria. The best culture medium available for the nonselective isolation and culture of rumen bacteria is an environment simulating medium containing rumen fluid; however, rumen fluid is not always available and is quite variable in composition. This indicated a need for a medium containing well standardized and readily available ingredients. Based on former nutritional studies of individual species, a culture medium, containing small amounts of yeast extract, trypticase and heme, and volatile fatty acids similar to those in rumen fluid to replace the rumen fluid, has been developed. Tests on cattle fed alfalfa hay-grain, cracked corn-urea, and cracked corn-soybean oil meal diets in this country, and cattle fed ground or long dried grass, in cooperative studies with English workers, indicate that in total counts and diversity of species grown the medium gives results similar to those obtained with the rumen fluid medium. A few types, including Methanobacterium ruminantium require unknown factors not present in the medium but present in rumen fluid. In this study a very unusual flora was found in some of the cattle on the cracked corn diets. Protozoa were often absent and the bacterial flora contained one species Selenomonas ruminantium in proportions as high as about 50% of the total population. Direct microscopic studies confirmed the cultural results. (AH h2-3)

E. Fish Silage

Animal feeding studies have been initiated comparing fish silage with other feed sources for cattle and chickens. (S9-AH-1)

F. Radiation Biology

1. Whole body irradiation. At Cornell, sheep were exposed to 500 r and 1000 r of external radiation from cobalt-60 sources. Internal radiation was studied by giving 40 mc. of iodine-131.

Sheep exposed to 1000 r developed severe fever in about 10 days and were close to death after 2 weeks. Sheep exposed to 500 r and the internal I-131 exhibited no fever or illness. Sheep exposed to 1000 r lost their wool and had a greatly reduced food and water intake during the 2-week period. There was a greater accumulation of Sr-85 in tissues of animals that had been irradiated. There was no effect on Co-134 accumulation.

2. Changing the calcium-strontium ratio in dairy feeds. All of the analytical work from the 1963 cooperative studies at Minnesota, Iowa, and Utah to determine the effect of altering calcium-strontium ratios in feeds has been completed. While the summarization of the data has not been completed, a number of tentative conclusions may be drawn from the results. The more important of these are:

- (a) Studies of various levels of concentrate in the diet suggest that the presence of concentrate may reduce Sr-90 milk levels and increase Cs-137 milk levels more than would be expected on the basis of dietary composition.
- (b) Cows grazing aftermath following the main herd had significantly higher Sr-89 and Sr-90 milk levels than cows grazing with the main herd. Similarly, the milk levels of cows on pasture were higher than those receiving the same forage or greenchop. These results suggest that the mat layer may be an important source of contamination and that any management procedure which forces the cows to graze more closely will tend to increase the milk levels of Sr-89 and Sr-90. During periods of rainfall the difference between treatments tended to disappear.
- (c) Data from groups of cows on controlled feed intake involving hay, silage, or greenchop as the source of roughage indicate that the level of Sr-90 secreted into milk is quite constant when expressed on the

basis of calcium. The values are similar to but may be somewhat lower than the values that have been obtained in tracer experiments.

- (d) In general, the relationship between the levels of Sr-90 in pasture samples and the levels of Sr-90 in milk of cows grazing the pasture was very poor. In view of the good results obtained in controlled feeding situations, it appears that the current pasture sampling practices leave much to be desired. Development of proper pasture sampling procedures would be a useful area for further study.
- (e) A number of changes of diet from high to low and low to high levels of dietary Sr-90 and Sr-89 were made. For all practical purposes the new milk equilibrium levels are reached in about 2 weeks. A more precise evaluation of the rate of change will be made. (AH h2-10C)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Genetics

- Kyle, W. H. and Goodale, H. D. 1963. Selection progress toward an absolute limit for amount of white hair on mice. Proc. XI International Congress of Genetics 1:154-155. (AH p-2)
- Wilson, S. P., Kyle, W. H., and Bell, A. E. 1963. Effect of mating systems on selection for pupa weight in *Tribolium*. Jour. An. Sci. 22(4): 1110-1111. (AH p-2)
- Kyle, Wendell H. 1964. Genetic research on directed evolution. Agri. Sci. Review 2(1):21-23. (AH p-2)
- Wilson, S. P., Kyle, W. H. and Bell, A. E. 1964. The effects of mating systems and selection on pupa weight in *Tribolium*. In press. Genetical Research. (AH p-2)
- D'Antonio, L. E. and Scheinberg, S. L. 1964. The detection and preparative separation of hemagglutinating antibodies following starch gel zone electrophoresis. Submitted for publication. (AH p-1)
- Scheinberg, S. L. and Wong, D. T. O. 1964. Serologic properties of Phaseolus lunatus lectin and other anti-A reagents. J. Immunol. 92:520-528. (AH p-1)

Scheinberg, S. L. and Reckel, R. P. 1964. The "Hi" agglutinin of chicken erythrocytes. Tenth Int. Cong. of Hematology and Blood Transfusion. Stockholm, Sweden. (AH p-1)

Wong, D. T. O. and Scheinberg, S. L. 1964. Studies of the agglutinins reactive with human A red cells. Proc. 9th Cong. Int. Soc. Blood Transf., Mexico 1962. pp. 507-516 (1964). (AH p-1)

Physiology

Bitman, J., Cecil, H. C., Gilliam, D. R., and Wrenn, T. R. 1963. Chemical composition of mammary gland during experimental mastitis. J. Dairy Sci. 46, pp. 933-940. (AH h5-1)

Bitman, J., Cecil, H. C., Gilliam, D. R., and Wrenn, T. R. 1963. Chemical composition of sheep mammary gland. J. Dairy Sci. 46, pp. 941-946. (AH h5-1)

Brinsfield, T. H., Hawk, H. W., and Leffel, E. C. 1963. Control by ovarian hormones of the acute inflammatory response in the sheep uterus. J. Reprod. Fertil. 6: pp. 79-86. (AH h5-8)

Brinsfield, T. H., Hawk, H. W., and Richter, H. F. 1964. Interaction of progesterone and estradiol on induced leukocytic emigration in the sheep uterus. J. Dairy Sci. 47, p. 706. (AH h5-8)

Cecil, H. R., Bitman, J., and Wrenn, T. R. 1964. Effect of histamine and estrogen on the glycogen content of the rat uterus. Endocrinology 74, pp. 701-708. (AH h5-8)

Hawk, H. W., Brinsfield, T. H., and Richter, H. F. 1963. Control by ovarian hormones of vascular permeability in normal and experimentally-infected sheep uteri. J. Reprod. Fertil. 6, pp. 71-77. (AH h5-8)

Hawk, H. W., Brinsfield, T. H., Turner, G. D., Whitmore, G. E., and Norcross, M. A. 1964. Effect of ovarian status on induced acute inflammatory responses in cattle uteri. Am. J. Vet. Res. 25, pp. 362-366. (AH h5-8)

Hawk, H. W., Brinsfield, T. H., Turner, G. D., Whitmore, G. E., and Norcross, M. A. 1963. Embryo survival in first-service and repeat-breeder cattle after ovariectomy and hormone therapy. J. Dairy Sci. 46, pp. 1397-1401. (AH h5-8)

Hawk, H. W., Brinsfield, T. H., and Turner, G. D. 1964. Effect of age and ovarian status on water and electrolytes in the sheep uterus. J. Animal Science 23, pp. 172-176. (AH h5-8)

Leppi, T. J. and Hawk, H. W. 1964. Histochemistry of mucopolysaccharides in the uteri of hormonally-treated rabbits. Anat. Record 148, p. 383. (AH h5-8)

Stettenheim, Peter, Lucas, Alfred M., Denington, Effie M., and Jamroz, Casimir. 1963. The arrangement and action of the feather muscles in chickens. Proc. 13th Intern. Ornithol. Congr. 1962. 2: 918-924. (AH e6-26)

Wrenn, T. R., Bitman, J., Cecil, H. C., and Gilliam, D. R. 1964. Uterine deciduomata: role of histamine. J. Endocrinology 28, pp. 149-152. (AH h5-8)

Rumen Function

Bryant, M. P. 1963. Symposium on microbial digestion in ruminants: Identification of groups of anaerobic bacteria active in the rumen. J. Animal Sci., 22, pp. 801-813. (AH h2-3)

Bryant, M. P. 1964. The bacteriology of the rumen. In press. In H. Henkelekian and N. Dondero (Ed.) Principle and Applications in Aquatic Microbiology. John Wiley and Sons, New York. (AH h2-3)

Bryant, M. P. 1964. Rumen methanogenic bacteria. In press. In R. W. Dougherty (Ed.) Second International Symposium on the Physiology of Digestion in the Ruminant. (AH h2-3)

Halliwel, G. and Bryant, M. P. 1963. The cellulolytic activity of pure strains of bacteria from the rumen of cattle. J. Gen. Microbiol. 32, 441-448. (AH h2-3)

Hungate, R. E., Bryant, M. P., and Mah, R. A. 1964. The Rumen Bacteria and Protozoa. Ann. Rev. Microbiol. (In press) (AH h2-3)

Pittman, K. A. and Bryant, M. P. 1964. Peptides and other nitrogen sources for growth of *Bacteriodes ruminicola*. J. Bacteriol. 88, #1 in press. (AH h2-3)

AREA NO. 2: BEEF CATTLE -- BREEDING

Problem. Expression of each of the productive and carcass traits of beef cattle varies from breed to breed and between animals within each breed. The beef cattle producer is constantly striving to achieve excellence in one or more of these traits. Frequently his failure to choose the best animals for breeding stock for the most effective mating program results in less than maximum progress. Often the beef cattle producer does not know how to identify, evaluate, and utilize the existing variability to achieve his aim. Research information is needed on heritability of economic traits in beef cattle, genetic and phenotypic correlation between these traits, effectiveness of various selection and breeding programs, and assessment of traits most useful in beef cattle improvement.

USDA AND COOPERATIVE PROGRAM

The beef cattle breeding research in the United States has developed as a coordinated program of the USDA and the State experiment stations. It is a continuing program of both applied and basic research carried on by geneticists, animal physiologists, and animal husbandmen. Early efforts in the improvement of beef cattle through performance testing were made by the USDA at Miles City, Montana, and Beltsville, Maryland. With the advent of regional research, efforts by the State stations were greatly increased and the individual programs were coordinated through regional research projects in three of the important beef cattle producing regions. This joint activity has been and remains characteristic of beef cattle breeding research, and the resulting program is an integrated effort combining to the best advantage the resources of the State experiment stations and the USDA.

The regional project in the South is S-10, Improvement of Beef Cattle for the Southern Region through Breeding Methods. Much of this region is subtropical in climate and in many cases cattle used in other areas are poorly adapted. Environmental conditions adversely affecting survival, reproductive regularity and growth are encountered. Research includes projects at 13 State stations and at the USDA stations at Jeanerette, Louisiana; Front Royal, Virginia; and Brooksville, Florida.

In the Western region the beef industry is largely geared to range conditions with many cattle shipped to areas of abundant grain supply for fattening. Ability to make maximum use of forage available on the range is an important consideration. These problems are studied through regional project W-1, The Improvement of Beef Cattle through the Application of Breeding Methods. Research includes projects at 12 State stations and at the USDA station at Miles City, Montana.

Similarly, NC-1, Improvement of Beef Cattle through Breeding Methods, is geared to problems of the beef industry in the North Central region where

beef is produced on farms with pastures of high productivity and ample grain supplies for feedlot finishing. Research includes projects at 12 State stations and at the USDA stations at Fort Robinson, Nebraska, and Fort Reno, Oklahoma.

The Federal scientific effort devoted to research in this area totals 16.1 professional man years. Of this number, 1.3 are devoted to performance testing, 4.4 to genetics and interrelations of performance traits, 1.2 to genetic-environmental interactions, 6.2 to selection and systems of breeding, and 3.0 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

To a greater degree than many other research programs, beef cattle breeding research has developed as a coordinated program of the USDA and the State agricultural experiment stations. This has been achieved to a large degree by cooperative research activities under three regional beef cattle breeding projects. This coordinated program is described amply by the material appearing under the USDA and Cooperative Program. The several examples cited describe research of a cooperative nature, much of it conducted at the State experiment station locations. The reader is referred to this section of the Division report with these comments, and no attempt will be made to summarize the State programs separately.

The total research effort on beef cattle breeding research by the State agricultural experiment stations is 40.5 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

As compared to other disciplines, knowledge accumulates slowly in Beef Cattle Breeding and Genetics due to (1) low reproductive rates, and (2) high maintenance and operational costs per animal; i.e., per genetic unit. In the material which follows an attempt has been made to include only items on which specific analyses were completed or summaries made during the year and to relate these to studies at other locations or in earlier years many of which have already been covered in progress reports of previous years.

A. Selection and Systems of Breeding

1. Effectiveness of selection for economically important traits. The estimates of genetic parameters; i.e., heritabilities and genetic correlations, give us a basis for projecting what genetic progress should be possible. However, only actual changes resulting from selection can be considered conclusive in determining progress actually possible. Most beef cattle breeding research herds have not been in existence for enough years or generations to permit good estimates of responses to selection. An exception to this generalization is the line 1 of Hereford cattle maintained at Miles City, Montana, under selection for growth and body conformation since its foundation in 1934.

An intensive study of amount and apparent effectiveness of selection in this line was completed during the year and, after allowing for trends in environmental levels, indicates genetic changes of +9.7 lb. in birth weight, +30.0 lb. in weaning weight and +6.5 points in weaning conformation score over a 25 year period.

The data did not permit accurate estimates of environmental time trends for postweaning performance traits. Gross or phenotypic time trends were positive and per generation amounted to 15 lb. in 196-day postweaning gain of bulls, 32 lb. in 18-month weight of heifers and 1.6 points in 18-month conformation score. Indications are that substantial portions of these changes are genetic, but exact estimates of the genetic portion are not possible. No intentional selection was made for mature cow weight but it increased substantially during the period under study.

This study strongly suggests that, for growth and conformation traits, response to selection was approximately as great as would be expected from previously calculated genetic parameters. (AH dl-2)

Another study on closed lines of Hereford cattle at Havre, Montana, indicated positive genetic trends for birth and weaning weights. (AH dl-17)

In a Nevada study, calves in lines selected for several years for rate of gain and economy of gain were 40 lbs. heavier at the end of the test period than calves from a line selected for conformation. Bulls from the rate of gain and economy of gain lines produced larger carcasses with greater rib area than carcasses from bulls in the conformation line. (AH dl-36)

Data from an Oregon study on selection techniques indicated that more progress could be made by testing and selecting animals in the environment under which the animals are expected to produce. (AH dl-19)

2. Crossbreeding. Data accumulating from several crossbreeding experiments continue to indicate important heterosis effects on several traits.

A comprehensive summary of the heterosis effects on preweaning traits was made at the completion of the first phase of the crossbreeding experiment at Fort Robinson, Nebraska. This study includes the Hereford, Angus, and Shorthorn breeds and all possible crosses among them. A total of 751 calves were involved with approximately equal numbers of crossbreds and straight-breds.

The summary showed a significant heterosis effect on birth weight, average daily gain from birth to weaning, weaning weight, and weaning conformation score. The heterosis effect on weaning weight was 19.4 lbs. The heterosis effect on weaning weight in the Hereford x Angus and reciprocal and Hereford x Shorthorn and reciprocal crosses was approximately one and three-fourths

times as great as in the Angus x Shorthorn and reciprocal cross. The analysis revealed that the heterosis observed could be attributed to breeds rather than to sires within breeds.

Additional data were collected during the year on the heterosis effects on postweaning growth and carcass characteristics. These results continue to reveal a heterosis effect for postweaning growth rate in both steers and heifers and a heterosis effect on feed efficiency in steers. Individual feed consumption has not been measured in the heifers. When slaughtered at the same age but at slightly heavier weights crossbred steers have had slightly fatter carcasses than the straightbreds.

Results continued to show a slight advantage for the crossbreds over the straightbreds in post-natal mortality. Crossbred females continue to reach puberty at younger ages. Crossbred females have required fewer services per conception, have conceived earlier in the breeding season with a higher percentage conceiving during a three-months breeding season. Crossbred cows have weaned calves approximately four percent heavier than straightbred cows with both groups of cows nursing crossbred calves. (AH dl-12)

A summary of five years of data at the Alabama station with British breeds indicated that crossbred steers had an advantage of 40 pounds in adjusted weaning weight over purebred steers, a 0.15 pound advantage in average daily gain up to weaning, a 70 pound advantage in chilled carcass weight, and slight advantages in grade over the purebred steers. When finished in a uniform feeding period, the crossbred steers were fatter (0.12 of an inch greater fat thickness over the rib eye), but there was no difference in meatiness or tenderness, as measured by rib eye per hundred pounds carcass and Warner-Bratzler shear, respectively. The crossbred heifers weaned heavier than purebred heifers. However, there were no differences in post-weaning performance between the two breeding groups. Two years' data with limited numbers suggests that crossbred dams are superior as mother cows. (AH dl-29)

Additional information from two stations on subsequent crosses after the single cross continues to indicate the advantages of crossbreeding schemes over straight-breeding systems. Three years' data from the Louisiana Station, involving single crosses, backcrosses, three-breed crosses, and straightbreds, indicate that the single crosses are slightly superior to backcrosses and three-breed crosses in rate of gain on feed, but the backcrosses and three-breed crosses excel the single crosses in adjusted weaning weight at 205 days. This indicated the advantage of the crossbred dam in calf production. The average weaning weight at 205 days for 93 straightbred calves involving Angus, Brahman, Brangus, and Hereford, was 390 pounds, as compared to 155 single cross calves averaging 418 pounds, 195 backcross calves averaging 459 pounds, and 194 three-breed cross calves averaging 463 pounds. The heavier weaning weights of crossbred calves, coupled with the higher percentage calf crop, give crossbred cows a substantial advantage over purebred cows in pounds of calf weaned per cow bred.

The Louisiana data are supported by work at the Virginia Station where calves from crossbred dams had a higher daily gain to weaning. This study is designed to breed purebred dams with crossbred bulls and crossbred dams with purebred bulls, so that all calves are, thus, either three-breed or back-crosses in all possible combinations of the three breeds - Angus, Hereford, and Shorthorn - involved. This permits an estimate of heterosis in the dams without confounding with heterosis in the calves. In one year's data from the Virginia Station, the crossbred dams had a calving percentage born of 97 percent, as compared to 92 percent for the purebred dams, but both the purebred and crossbred dams weaned 88 percent calf crops. (AH d1-7)

Studies in progress in Ohio and at Miles City, Montana, as well as the Louisiana study, indicate rapid rates of gain for the Charolais and heterosis in both pre- and postweaning gain for crosses of this breed with British breeds.

Crosses of Charolais and Brown Swiss with British breeds have consistently resulted in faster growth than in the British breeds. (AH d1-1, AH d1-10)

In addition to evaluation of total fertility, studies are underway at several locations on heterosis effects on some of the traits of apparent low heritability contributing to or related to the total reproductive process. Age at puberty has been reduced in crossbreds as compared with averages of the parental breeds. The crossbred-straightbred difference is greater at low levels of nutrition. Weight differences are not as great as age differences in puberty leading to the conclusion that the earlier attainment of puberty by crossbred heifers is at least in part accounted for by more rapid growth rates. Breed differences in age at puberty are large with Zebu types being older. This tendency is also transmitted in crosses. (AH d1-30, AH d1-33, AH d1-37)

At Miles City, Montana, attainment of puberty by crossbred and purebred bulls is being studied with the criteria being ages first ejaculation, production of sperm, production of motile sperm and production of sperm in adequate numbers for classification. In all criteria the crossbreds have been younger than straightbreds. (AH d1-33)

In the limited number of observations yet made, the interval from parturition to first estrus has been slightly but probably not significantly shorter in crossbred cows as compared to averages of the parental breeds. Conception rate at first service has been markedly better. (AH d1-30, AH d1-37)

3. Inbreeding and linecrossing. Inbreeding studies are of a long-time nature and the results of the two summaries discussed below must be considered as progress reports. In the mildly inbred line 1 Herefords at Miles City, Montana, increased inbreeding had a detrimental effect on all traits studied. The effect of inbreeding on weight reached a peak at 18 months of age in heifers and declined somewhat at mature weights. Final weight off

test (12-13 mo.) was affected more by increased inbreeding than weights taken earlier in life in bulls.

Increases in inbreeding of dam had a detrimental effect on growth from birth to weaning and weaning weight, presumably through decreased milk production. This effect was completely compensated for at 18-month weight in heifers and was greatly reduced in bulls for final weight off test (12-13 mo.).

There was a differential response by sex to inbreeding of calf and inbreeding of dam in weanling traits. Inbreeding of calf had a more pronounced effect on females than on males, whereas inbreeding of dam had a greater effect on preweaning gain, weaning weight, and weaning score of bulls than on heifers. It is postulated that bulls, having a greater growth potential, are held back more than heifers by the decreased milk supply of their dams that is associated with increased inbreeding of dam. This maternal environment may mask the response to inbreeding of calf in bull calves to a greater extent than in heifers.

In the selection study utilizing these same data discussed in an earlier section, a tendency was found to select replacement breeding animals with lower than average levels of inbreeding. Since no intentional or direct selection was made for less highly inbred animals, the tendency to select less inbred animals was due to their higher performance. It is also likely that selected individuals may be less homozygous than their calculated inbreeding coefficients would indicate. (AH d1-2)

Data from the inbreeding study at the Front Royal, Virginia, Station, where "type" and "growth" data on 2440 calves from birth to weaning were analyzed, indicate large differences among lines in response to inbreeding. This is shown by the difference between foundation and inbred lines for birth and mid-summer weights, gain to weaning, and weaning type score. Weights and gains of the calves from the "growth" herd exceeded those of the "type" calves, and, conversely, "type" calves had higher conformation than did "growth" calves. Response to inbreeding of calf and of dam was nearly opposite in Angus and Shorthorn calves. For example, in Angus each additional 1 percent inbreeding of the calf decreased average daily gain to weaning by -.0056 pounds; whereas, in Shorthorns, the value was -.0031 pounds. In contrast, similar regressions on percent inbreeding of the dam were -.0012 pounds for Angus and -.0047 pounds for Shorthorns. (AH d1-4)

Results to date from crossing inbred lines show heterosis as compared to line performance and strongly suggest fairly important specific combining ability for some traits with results from year to year being consistent. (AH d1-2, AH d1-16)

B. Performance Testing

Attention to improving methods for evaluating performance in beef cattle is continuous in most projects. The most significant overall recent trends are

increased attention to (1) carcass evaluation, including methods of estimating carcass characteristics from live animals, and (2) evaluation of fertility and the components or factors upon which it depends. Routine evaluations of these traits will make more comprehensive future genetic analyses possible.

1. Carcass traits. Genetic improvement of carcass traits must be based on progeny tests and is bound to be slow and expensive unless or until ways of better estimating potential carcass characteristics of live animals can be developed. For this reason, this problem is receiving major emphasis.

The Thermistor Thermometer is a highly sensitive instrument which, when inserted through a small slit in the skin, measures differences in temperature of fat and lean. This permits estimates of fat thickness. In two studies correlations of +.5 and +.62 were observed between estimated live fat thickness and carcass fat thickness at the 12th rib. (AH d1-31, AH d1-12)

Ultrasonic devices permit estimates of fat thickness and depth of muscles through measurement of reflected ultra-high frequency sound waves from tissue interfaces. A number of studies show correlations of +.6 to +.8 between live estimates of fat thickness and rib eye area and carcass measurements. There is evidence of operator and machine differences. (AH d1-8, AH d1-9, AH d1-12)

A Utah study indicated promise for a simple probe device as a means of estimating fat thickness in live animals and a high correlation between its estimates and those of a new ultrasonic device. (AH d1-20)

In a comprehensive study involving subjective evaluation of certain carcass characteristics in live cattle, the correlations between live estimated fat thickness and fat thickness measured in the carcass were in the .5 to .6 range. The estimates involving actual percent of trimmed, boneless retail cuts from the round, loin, rib and chuck showed correlations in the .5 to .6 range. Subjective live estimates of rib-eye area; percent kidney, pelvic and heart fat; and carcass grade gave lower correlations; i.e., in the .3 to .5 range. In this study it was indicated that market interests can subjectively estimate percent trimmed, boneless retail cuts from the round, loin, rib and chuck (cutability) with precision adequate to justify use of the dual grading concept when working with groups as large as five cattle. (AH d1-12)

To summarize, it appears that progress is being made in this area with the human eye, trained in what to look for, being almost as effective as the various mechanical and electronic devices studied to date.

In two studies on variability in yield of trimmed retail cuts, it was found that live and/or carcass weight accounted for more of the variation than other carcass variables. (AH d1-22, AH d1-12)

In one of these studies a correlation of .94 was obtained between live weight and pounds of retail product after adjusting for age and breeding group

effects. Carcass weights and measurements added little to age adjusted live weight in predicting pounds of retail product. The interpretation that can be put on these results is that variations in age adjusted live weight are appreciably greater than variations in carcass composition on the same basis. Thus, live weight differences at the same age seem to account for most of the variation in pounds of retail product on a within breeding group basis. (AH d1-12)

2. Conformation scores. In a study of classification (conformation evaluation) in cattle of reproductive age, it was found that classifiers differ appreciably in their repeatability of evaluations and that repeatability tends to be lower when evaluating younger cows. Some classifiers had a correlation of .9 or greater in successive scorings of the same animal at different times. (AH d1-31)

3. Growth rates. Additional studies have been made of effects of sex and age on performance to weaning. One of these on Virginia BCIA data involved over 28,000 records in many herds. The results confirm the general validity of results previously summarized on smaller bodies of data from experiment stations in the same general geographic area and with the same breeds (Hereford and Angus). Upward adjustments of 10, 5, 3, 2, and 3 percent were found necessary to adjust calf weaning weights of calves from 2, 3, 4, 5, and 12 years of age and older dams, respectively, to the average of weights of calves from cows 6 - 11 years of age. (AH d1-7)

A study on cow and calf weights at the Texas Station, involving a large amount of data on Hereford, Brahman, and Hereford-Brahman crosses, indicated that there was a rather uniform increase in average calf weight as dam weight increased up to 1050 pounds, a leveling-off of calf weights when dam weights increased from 1050 to 1300 pounds, and a decrease in calf weights as cow weights increased up to 1350 pounds. It appears that weaning weight selection would be more efficient if dam weight were taken into consideration.

In an analysis of a large volume of Oklahoma data on environmental effects on preweaning traits, it was found that the sex effect was greater in creep-fed than in noncreep-fed calves. However, the age of dam effects were quite similar in both creep-fed and noncreep-fed calves. (AH d1-31)

From twin data, birth weight, butter fat production from 0 to 60 days, creep feed consumed and sex had a highly significant influence on weaning weight; the standard partial regression coefficients ranging from .30 to .42. (AH d1-43)

Postweaning gains made during the first 28 days on feed were more highly correlated with total gains than was any other gain period. The effects of initial age on postweaning gains were negligible while the effects of initial weight were more important in steers started on feed at 13 and 18 months of age than in steers started on feed at 8 months of age. (AH d1-10)

A limited amount of data continued to indicate the feasibility of producing 1000-pound calves in a year or less. The goal of producing 1000-pound calves at weaning is probably several generations in the future. However, data from the Texas Station show that a group of steers from various breed groups, which were managed and fed to gain a maximum, averaged 963 pounds at 365 days of age, as compared to 973 pounds last year. Some of the breed groups exceeded 1000 pounds at one year of age. (AH d1-22)

Performance test information is being gathered in virtually all research herds. In several instances, sires are progeny tested before they are used extensively in selection herds. At the Alabama Station, a total of twelve 140-day postweaning performance tests have been completed. During the first 10 years, a total of 517 bulls completed the test with an average daily gain of 2.24 pounds and a weight per day of age of 2.06 pounds; while during the last two years, 139 bulls completed the test with an average daily gain of 2.42 pounds and a weight per day of age of 2.29 pounds. The top third of the bulls gained an average of 2.73 pounds daily during the last four years, as compared to the lowest third which gained 2.14 pounds daily. These bulls brought an average sale price of \$775.00 and \$475.00, respectively. Weight per day of age was also evidently considered in buying bulls, since the top third, with a weight per day of age of 2.46 pounds, brought an average of \$767.00 per head, as compared with 2.09 pounds and \$482.00 per head for the lower third. (AH d1-29)

At the Tennessee Station, two methods of developing and testing herd bulls from weaning to approximately 20 months of age are being compared. During the past year, 41 Hereford and Angus bull calves from various Tennessee sub-stations were used in this experiment. Representative bulls from each method will be progeny tested on random groups of cows to determine which method serves as a better indicator of the progeny's growing ability. (AH d1-9)

It appears from Arizona data, in which cattle were maintained year round on the range, that weight after stress might be about the best single growth trait for which bulls could be selected. This was based on the expected responses of other growth traits to such selection. Data on heifers indicate that fall yearling weight would be the best single growth trait on which to base selection. (AH d1-14)

C. Genetics and Interrelationships of Performance Traits

1. Heritability of quantitative traits. In a study with identical and fraternal twins, heritabilities were found of .80 for feed efficiency, .88 for 8-month milk production, .90 for 8-month fat production, .45 to .91 for several body measurements, and 0 for age at first calving. With the exception of age at first calving, these estimates are considerably higher than those usually found in non-twin herds. (AH d1-43)

In an extensive study utilizing data from breeders' herds in Virginia, heritabilities of preweaning average daily gain, weaning grade and an index

based on both gain and grade were found to be near 35 percent for Angus calves - again close to experiment station estimates. Heritabilities for Herefords were slightly under 30 percent. (AH d1-7)

A heritability estimate of .11 for pounds of carcass fat adjusted for differences in carcass weight was found. The estimate for pounds of carcass lean on the same basis was .0. Thus, these results suggest that there is not a great amount of genetic variation in composition on a weight constant basis when evaluating cattle of the same general type of the same breed. In the same study, estimates of heritability for growth traits, conformation score, marbling and rib-eye area were all high; i.e., in the .4 to .6 range. The genetic correlation between final weight and marbling score was positive and the genetic correlation between final weight and weight adjusted pounds of carcass fat was a high negative.

In an analysis of data from the same source an attempt was made to predict pounds of edible portion of the carcass from certain blood constituents. In a multiple correlation study an R^2 of approximately .5 was obtained between several blood constituents and pounds of edible portion. (AH d1-13)

2. Genetic correlations. In an analysis of growth and carcass data no major genetic antagonisms were indicated between the traits that contribute to productive efficiency and desirable carcass traits. However, in this study a high positive genetic correlation was obtained between outside fat and carcass grade (marbling). The phenotypic correlation between outside fat and carcass grade was a low positive while the environmental correlation was negative. (AH d1-31)

3. Genetic-environmental interactions. Data were studied from 104 steers slaughtered in 1962 and 1963 in a North Carolina study in which bulls are bred artificially to cows in each of three herds in different geographic areas of the State.

Twenty-five items relative to live weight carcass measurements and cooked steaks were considered in the analyses. Main effects; i.e., location, ration, sire, and year, were significant for most carcass measurements, and ration significantly affected taste panel scores for juiciness and flavor. Interaction between ration and year was significant for percent dress, marbling score, and carcass grade. The only indication of a genetic-environmental interaction was in percent separable lean in the 9-10-11th rib cut. Heifers which are progeny of sires used in this project are calving for the first time in 1964, and data on cow performance will soon be available for further consideration of interactions. (AH d1-23)

The genetic-environmental interaction study at Brooksville, Florida, which is an interregional cooperative study between that station and Miles City, Montana, is now in its third year. Adaptation of cattle from one station to the other has been relatively good, although some differences in shedding of hair and growth rate of calves has been noticed. (AH d1-41)

4. Genetic defects. A study of snorter dwarfism, as well as other types of dwarf anomalies in beef cattle, is being continued at the Florida Experiment Station. Dwarf x dwarf, dwarf x carrier, dwarf x normal, and normal x normal matings have been made in order to study the biochemical abnormalities in body fluids and tissues which may serve to identify carriers of the dwarfism trait. Embryos have been removed at 40, 60, and 90 days of age and the cows returned to the breeding herd to be bred again. This is an attempt to bracket the stage of development when the dwarf gene action is apparent. At present, 18 embryos of varying ages have been recovered and are being studied. Techniques are still being perfected for the culture of bovine leucocytes for cytogenic studies. (AH d1-34)

Dwarfism research is being continued at the Tennessee Station in a limited way. Known dwarf tester cows have been assembled and are being used to check herd sire prospects for possible dwarf genes. (AH d1-9)

In an analysis of data involving the profilometer technique for identification of carriers of snorter dwarfism a product moment correlation of 0.36 was obtained between predicted and actual genotype. This was significant at the .05 level of probability. However, this level of accuracy is considered too low to be useful in identifying genotypes relative to the snorter dwarf gene. (AH d1-13)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

General

Bovard, K. P. and Priode, B. M. 1963. Research with beef cattle at the Front Royal Station. Va. Agr. Expt. Sta. Res. Bull. 547. (AH d1-4)

Clark, R. T.; Brinks, James S.; Bogart, Ralph; Holland, Lewis A.; Roubicek, Carl B.; Pahnish, O. F.; Bennett, James A.; and Christian, Ross E. 1963. Beef cattle breeding research in the Western Region. Ore. Agr. Expt. Sta. Tech. Bull. 73. (AH d1-1, AH d1-2, AH d1-14, AH d1-16, AH d1-17, AH d1-18, AH d1-19, AH d1-20, AH d1-25, AH d1-36, AH d1-39, AH d1-40)

Selection and Systems of Breeding

Bellows, R. A.; Riley, R. M.; Kieffer, N. M.; Urick, J. J.; Brinks, J. S.; and Clark, R. T. 1964. Preliminary studies of sperm production and breeding ability in young straight and crossbred bulls. Am. Soc. Anim. Sci., West. Sect. Proc. 15: (Abs. J. Anim. Sci. 23: 593-94). (AH d1-33)

Carroll, F. D.; Rollins, W. C.; and Simone, Marian. 1964. Herefords and 1/4 Brahman - 3/4 Hereford crossbreds: Comparison of carcasses and meat palatability. J. Agr. Sci. 62: 263. (AH d1-40)

Carter, R. C.; McClure, W. H.; Gaines, J. A.; and Vogt, D. W. 1963. Heterosis from crosses among British breeds of beef cattle. "Genetics Today," Proc., XI Int. Cong. of Genetics, I: 265 (Abs.) (AH d1-7)

- DeRouen, T. M.; Reynolds, W. L.; and High, Jr., J. W. 1963. Evaluation of the Sindhi breed for beef at the Iberia Station. J. Anim. Sci. 22: 43 (Abs.) (AH d1-6)
- Ellis, Jr., G. F., and Cartwright, T. C. 1963. Heterosis in Brahman-Hereford crosses. J. Anim. Sci., 22: 817 (Abs.) (AH d1-22)
- England, Noah; Robertson, G. L.; and Sullivan, J. S. 1963. A comparison of four mating systems for beef cattle production. J. Anim. Sci. 22: 817 (Abs.) (AH d1-6)
- England, Noah; Temple, R. S.; and Farthing, B. R. 1963. The effect of breed of dam and lactation status upon conception rate in beef cattle. J. Anim. Sci., 22: 818 (Abs.) (AH d1-6)
- Flower, A. E.; Brinks, J. S.; Urick, J. J.; and Willson, F. S. 1963. Comparisons of inbred lines and line-crosses for performance traits in Hereford range cattle. J. Anim. Sci. 22(4): 914-918. (AH d1-2)
- Flower, A. E.; Brinks, J. S.; Urick, J. J.; and Willson, F. S. 1964. Selection intensities and time trends for performance traits in range Hereford cattle under mass and recurrent selection. J. Anim. Sci. 23(1): 189-195. (AH d1-2)
- Pahnish, O. F.; Brinks, J. S.; Roberson, R. L.; Roubicek, C. B.; and Clark, R. T. 1964. Factors associated with growth of range cattle. Am. Soc. Anim. Prod., West. Sect. Proc. 15: IV. (Abs., J. Anim. Sci. 23: 591-92.) (AH d1-14)
- Reynolds, W. L.; DeRouen, T. M.; and High, Jr., J. W. 1963. The age and weight at puberty of Angus, Brahman, and Zebu-cross heifers. J. Anim. Sci. 22: 243. (Abs.) (AH d1-30)
- Rollins, W. C.; Carroll, F. D.; and Ittner, N. R. 1964. Comparison of the performance of 3/4 Hereford - 1/4 Brahman calves with Hereford calves in a variable climate. J. Agr. Sci. 62(1): 83. (AH d1-40)
- Vogt, D. W.; Gaines, J. A.; McClure, W. H.; and Carter, R. C. 1964. Post-weaning performance of crossbred vs. straightbred calves. J. Anim. Sci. 22: 306. (Abs.) (AH d1-7)
- Willham, R. L. and Stephens, D. F. 1964. Beef cattle selection studies. Okla. Agr. Expt. Sta. MP-74: 74-78. (AH d1-31)
- Willson, F. S.; Flower, A. E.; Kieffer, N. M.; and Miller, R. W. 1963. Topcross tests of R.O.P. and visually selected herds of Hereford cattle. Am. Soc. Anim. Sci., West. Sect. Proc. 14:XIII. (Abs., J. Anim. Sci. 22: 823) (AH d1-17)

Wilson, L. L.; Dinkel, C. A.; and Minyard, J. A. 1961. Beef cattle selection indexes involving conformation and weight. J. Anim. Sci. 22: 1086-1090. (AH d1-13)

Performance Testing

Bogart, Ralph; Ampy, Franklin R.; Anglemier, Allen F.; and Johnson, Jr., W. K.; 1963. Some physiological studies on growth and feed efficiency of beef cattle. J. Anim. Sci. 22(4): 993-1000. (AH d1-19)

Brinks, J. S.; Clark, R. T.; Kieffer, N. M.; and Urick, J. J. 1964. Predicting wholesale cuts of beef from linear measurements obtained by photogrammetry. J. Anim. Sci. 23(2): 365-374. (AH d1-2)

Brown, C. J.; Lewis, Jr., P. K.; and Heck, M. C. 1963. The relationship between performance test information and carcass cut-out data and eating quality of steaks from beef bulls. Ark. Agr. Expt. Sta. Bull. 676. (AH d1-8)

Gregory, P. W.; Shelby, C. E.; and Clark, R. T. 1963. Growth of Hereford cows selected and rejected for breeding. Growth 27: 205. (AH d1-40)

Lagos, F. and Cartwright, T. C. 1963. Sire-environmental interaction of gain in cattle. J. Anim. Sci. 22: 820 (Abs.) (AH d1-22)

Reynolds, W. L.; DeRouen, T. M.; and High, Jr., J. W. 1963. The effect of growth rate on calving percentage of Brangus and Africander-Angus heifers. J. Anim. Sci. 22: 821 (Abs.) (AH d1-30)

Van Arsdel, William C., III; Krueger, Hugo; and Bogart, Ralph. 1963. Age changes in the EKG of beef cattle. Ore. Agr. Expt. Sta. Tech. Bull. 70. (AH d1-19)

Van Arsdel, William C., III; Krueger, Hugo; and Bogart, Ralph. 1963. Vector orientation of P, QRS, and T axes in beef cattle. Am. J. Vet. Res. 24 (102): 956. (AH d1-19)

Wilson, L. L.; Dinkel, C. A.; Tuma, H. J.; Ray, D. E.; and Breidenstein, B. C. 1963. Prediction of edible portion and fat trim of beef cattle from live scores and measurements. J. Anim. Sci. 22: 1110 (Abs.) (AH d1-13)

Wiltbank, J. N. and Harvey, W. R. 1963. Reproductive performance of beef cows in Louisiana. J. Anim. Sci. 22: 823 (Abs.) (AH d1-30)

Genetics and Interrelationships of Performance Traits

Cole, J. W.; Ramsey, C. B.; Hobbs, C. S.; and Temple, R. S. 1963. Effects of type and breed of British, Zebu, and dairy cattle on production, palatability, and composition. I. Rate of gain, feed efficiency, and factors affecting market value. J. Anim. Sci. 22:702-707. (AH d1-9)

- Cundiff, L. V.; Chambers, D.; Stephens, D. F.; and Willham, R. L. 1964. Genetic analysis of some growth and carcass traits in beef cattle. J. Anim. Sci. 23: 297 (Abs.) (AH d1-31)
- Julian, L. M.; Tyler, W. S.; and Gregory, P. W. 1964. Expression of modified achondroplasia in domestic cattle as reflected by early closure of the spheno-occipital synchondrosis. (Abs.) Anat. Rec. 148: 296. (AH d1-39)
- Marlowe, T. J. 1963. Variations among homozygous dwarf, heterozygotes, and homozygous normal beef cattle. Va. J. Sci., Proc. 14: 170. (AH d1-35)
- Marlowe, T. J. 1964. Evidence of selection for the Snorter dwarf gene in cattle. J. Anim. Sci. 23: 454-460. (AH d1-35)
- Miquel, C. A. and Cartwright, T. C. 1963. Comparison of heritabilities in crossbred and purebred cattle. J. Anim. Sci., 22: 821. (Abs.) (AH d1-22)
- Pahnish, O. F.; Roberson, R. L.; Taylor, R. L.; Brinks, J. S.; Clark, R. T.; and Roubicek, C. B. 1964. Genetic analysis of economic traits measured in range-raised Herefords at preweaning and weaning ages. J. Anim. Sci. 23(2): 562-568. (AH d1-14)
- Ramsey, C. B.; Cole, J. W.; Meyer, B. H.; and Temple, R. S. 1963. Effects of type and breed of British, Zebu, and dairy cattle on production, palatability, and composition. II. Palatability differences and cooking losses as determined by laboratory and family panels. J. Anim. Sci. 22: 1001-1008. (AH d1-9)
- Sittmann, K. 1963. Note on the double cervix condition in cattle. J. Hered. 54: 112. (AH d1-39)
- Temple, R. S.; Jamison, H. M.; and Kincaid, C. M. 1964. Reproductive performance of beef cattle in the South. J. Anim. Sci. 23: 305. (Abs.) (AH d1-9)

AREA NO. 3: BEEF CATTLE -- PHYSIOLOGY

Problem. The loss resulting because of poor reproductive performance is hard to estimate. Data available from a 200 cow herd over a four-year period indicates that 10,490 potential pounds of calf were lost for each 100 cows bred. Thirty percent of the loss was because cows calved late and 70% because cows failed to wean a calf. Failure to show heat in the early part of the breeding season, or cows not settling on first service were the reasons for late calving. Most cows not weaning a calf in the fall were never diagnosed pregnant. These cows either did not show heat or they were bred and did not settle. Methods must be developed so that a higher proportion of cows will calve and will calve over a shorter period of time. In order to accomplish this, all cows must show estrus the first 21 days of the breeding season and a high proportion must settle at first service. This cannot be accomplished unless more information on physiological processes involved is available.

USDA AND COOPERATIVE PROGRAM

The program at the present time is mainly concerned with methods of improving, controlling or altering reproductive performance by hormonal, nutritional or other methods. It is carried on by physiologists and animal husbandmen at Beltsville, Md., and at the Department's Fort Robinson, Nebr.; Miles City, Mont.; Jeanerette, La.; and Fort Reno, Okla., stations in cooperation with the respective State experiment stations. Studies on the causes of reproductive failures are conducted with the herds at all these locations. Investigations on the relationship between reproductive performance and protein and energy intake levels are in progress at Beltsville, Fort Robinson, Jeanerette, Miles City, and Fort Reno to determine the relationship between anatomy of the pelvis and calving difficulties. Studies are underway at Fort Reno and Fort Robinson on control of the estrous cycle. Work at Fort Reno is designed to determine methods for altering the onset of post-partum estrus. Work at Miles City is designed to determine methods for inducing twin ovulations and thus twin births in beef cattle. Other studies at Fort Robinson include causes of maintenance and regression of the corpus luteum and methods to hasten the onset of puberty.

The Federal scientific effort devoted to research in this area totals 2.6 professional man years of which 2.2 are devoted to physiology of reproduction and .4 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

In addition to the research reviewed under Physiology in the Animal Biology problem area, several stations are conducting investigations designed specifically for beef cattle. These studies include the effect of controlled temperature and hormones on reproduction in heifers of both Brahman and

British breeding, the nature of sterility in animals which leave herds because of failure to reproduce, and research designed to more clearly define fundamental principles related to ova transfer and to develop a technique for collection and transfer of ova without surgery. Investigation of physiological effects of various hormone substances and development of simplified methods for bringing groups of animals into estrus within a short period is the objective of other research. Basic studies will determine the site of maturation of sperm and if proven to take place in the uterus, attempts will be made to isolate the material responsible for maturation.

Research in environmental physiology includes developing biological measures of response to environmental stress under controlled conditions, procedures for measuring environmental responses under field conditions, and the effect of nutrient restriction following weaning on the growth of heifers and upon subsequent lifetime production.

Other studies seek to explain the action of hormone compounds in promoting growth and the effect of levels of milk and forage intake at different periods on gain and weaning weight of beef calves.

The total State scientific effort devoted to beef cattle physiology research is 4.8 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Nutrition and reproduction. Studies are being conducted at all stations to determine the effects of different levels of energy on the reproductive performance of beef females. At two stations, heifers were fed different levels of feed in drylot before and after calving. Death loss of calves was high in the extremely fat heifers while little difference in loss was noted between heifers on low levels of feed and those on a moderate level. The proportion of heifers becoming pregnant was increased when heifers were on a high level of feed following calving. Onset of heat following calving was delayed in heifers receiving the low levels of feed prior to calving. Although the proportion becoming pregnant in a 60-day breeding season was as high or higher for heifers fed the low levels as it was in heifers fed the high levels of feed prior to calving. The interval from calving to first heat was decreased when an increased level of energy was fed for 45 days before calving. (AH d1-37, AH d2-22)

Studies of various levels of supplemental feeding on range are being conducted at three stations to determine the effects on reproduction in beef heifers. Birth weight of calves from heifers on the low levels of feed were lower compared to calves from heifers on a higher level of feeding. The breeding date for heifers was delayed by low nutrition. (AH d2-12, AH d1-33, AH d2-34)

An experiment has been conducted at Front Royal Beef Cattle Research Station to assess the value of feeding or injecting vitamin A on calf survival. Neither the dam's supplementation nor the injection of calves with vitamin A influenced the post partum survival of the calf. (AH dl-4)

2. Inducing early puberty. At Fort Robinson, 21 prepuberal heifers were treated with synthetic hormones to determine if puberty could be induced early. All heifers except one receiving estradiol valerate either intramuscularly or intravenously, showed heat. However, only one heifer ovulated and regular estrus cycles were not established in any of the heifers. One heifer out of five receiving the alpha estradiol and the hydroxyprogesterone cap roate showed heat. Ovulation was not induced in either case and a regular cycle was not established. (AH dl-37)

At Jeanerette, 16 heifers were injected with progesterone and estradiol. Thirteen of these heifers showed heat at the end of the treatment. (AH dl-30)

3. Losses at or near calving. Studies to determine the association between pelvic opening size, calf size and calving difficulty have been conducted at Fort Robinson and Miles City. Summarization of these data show that calving difficulty can be predicted quite readily in heifers having their first calf at 3 years of age; while prediction in heifers calving at 2 years of age is rather uncertain. Data from Hereford dams indicate a high correlation between calf birth weight and body measurements. Male calves were larger than female calves in all measurements taken. (AH dl-37, AH dl-33)

4. Inducing multiple ovulations. An exploratory study of the effects of insulin and gonadotropin (PMS) on ovarian activity in beef heifers has been conducted at Miles City. PMS treatment increased: number of follicles 75 mm. diameter (1.5 vs. 5.8, $P < .01$); ovarian follicular fluid weight (1.76 gm. vs. 7.04 gm., $P < .01$); and number of corpora lutea (1.00 vs. 3.67, $P < .05$) all figures no PMS vs. PMS, respectively. Insulin treatment main effects were non-significant as were all insulin x PMS interactions. However, there was an indication that concomitant insulin treatment with the PMS reduced the individual animal response variation in ovarian activity obtained when PMS was given alone. (AH dl-33)

5. Control of estrus. Synchronization of heat has been studied at Fort Robinson and Fort Reno by feeding oral progestins alone or in combination with stilbestrol, and by injecting progesterone and estradiol valerate. Feeding Provera (Upjohn and Co.) for 18 days successfully synchronized heat in a 4-day period for heifers on a high level of feed but not in heifers on a low level. Conception rate was low. Feeding Droxone (E. R. Squibb and Co.) for 20 days synchronized heat in a 3-day period. Conception rate at first service was low. Studies indicate that this is the result of a low fertilization rate. Length of heat period and time of ovulation were also affected by synchronization. Attempts to decrease the amount of Droxone needed by addition of stilbestrol to the Droxone were not successful. However, it was demonstrated that heat could be successfully synchronized by feeding Droxone

for 9 days if heifers were given a single injection of estradiol valerate. Preliminary results indicate a conception rate comparable to the controls.

Heat was also successfully synchronized by 12 daily injections of progesterone and estradiol valerate. (AH d2-12)

The influence of small injections of estradiol-17 beta on ovarian activity was studied in 120 cycling heifers. Injections ranged from 20 mcg. daily to 640 mcg. daily. All levels of estrogen reduced luteal activity and follicular growth and development. The inhibition of ovarian activity was approximately proportional to the level of estradiol administered. (AH d1-37)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

Bellows, R. A., Riley, T. M., Kieffer, N. M., Urick, J. J. 1964. Exploratory studies of the effects of insulin and gonadotropin (PMS) on ovarian activity in beef heifers. Am. Soc. of Animal Sci., West. Sect. Proc. 15: p VI. (Abs in J. Animal Sci. 23(2): 593.) (AH d1-33)

Bellows, R. A., Riley, T. M., Kieffer, N. M., Urick, J. J., Brinks, J. S., and Clark, R. T. 1964. Preliminary studies of sperm production and breeding ability in young straight and crossbred bulls. Am. Soc. Animal Sci., West. Sect. Proc. 15: p I. (Abs. in J. Animal Sci. 23(2): 593-594). (AH d1-33)

Bond, J., Wiltbank, J. N., Warwick, E. J., Lehmann, R. P., and Kinney, T. B. 1964. Feed intake and milk production of beef cows. J. Animal Sci. 23: 901. (Abs.) (AH d2-22)

DeRouen, T. M., Reynolds, W. L., and High, Jr., J. W. 1963. Evaluation of the Sindhi breed for beef at the Iberia Station. J. Animal Sci. 22: 243 (Abs.) (AH d1-30)

Dunn, T. G., Wiltbank, J. N., Zimmerman, D. R. and Ingalls, J. E. 1964. Energy level and reproduction in beef females. Am. Soc. Animal Sci., West. Sect. Proc. 15: (Abs. in J. Animal Sci. 23(2): 594) (AH d1-37)

Niswender, G. D., Kaltenbech, C. C., Shumway, R. P., Wiltbank, J. N. and Zimmerman, D. R. 1964. Ovarian activity as modified by estrogen. Am. Soc. Animal Sci., West. Sect. Proc. 15: (Abs. in J. Animal Sci. 23(2): 594) (AH d1-37)

Reynolds, W. L., DeRouen, T. M. and High, Jr., J. W. 1963. The age and weight at puberty of Angus, Brahman and Zebu cross heifers. J. Animal Sci. 22: 243. (Abs.) (AH d1-30)

- Reynolds, W. L., DeRouen, T. M., and High, Jr., J. W. 1963. The effect of growth rate on calving percent of Brangus and Africander-Angus heifers. J. Animal Sci. 22: 821. (Abs.) (AH d1-30)
- Turman, E. J., Smithson, L., Pope, L. S., Renbarger, R. E., and Stephens, D. F. 1964. Effect of feed level before and after calving on the performance of two-year-old heifers. Okla. Agr. Expt. Sta. Misc. Publ. MP 74: 10. (AH d2-12)
- Weldy, J. R., McDowell, R. E., Bond, J. and Van Soest, P. J. 1964. Responses of winter-conditioned heifers to prolonged heat stress. J. Dairy Sci. 47(6): 691-692. (Abs.) (AH d2-22)
- Weldy, J. R., McDowell, R. E., Van Soest, P. J., and Bond, J. 1964. Influence of heat stress on rumen acid levels and some blood constituents in cattle. J. Animal Sci. 23(1): 147-153. (AH d2-22)
- Wiltbank, J. N., and Harvey, W. R. 1963. Reproductive performance of beef cows in Louisiana. J. Animal Sci. 22: 823-824. (Abs.) (AH d1-30)

AREA NO. 4: BEEF CATTLE -- NUTRITION AND MANAGEMENT

Problem. Producers of beef cattle need improved feeding methods which will result in optimum pasture and feedlot gains, reduced feed consumption per pound of beef produced, optimum reproductive rates and desired carcass qualities. To meet these needs basic nutritional information is required such as: When should beef animals be fed for maximum gains and when for more limited gains? What nutrient combinations produce rapid growth of muscle with a minimum of fat deposition? How may breeding animals be economically raised that will be capable of a high level of reproductive performance over a long lifetime? What are the nutritive contributions made by range and pasture and what supplementation is required when they are used? Research is also needed on the relation between animal production and types of shelters and equipment, feeding systems, and methods of increasing labor efficiency.

USDA AND COOPERATIVE PROGRAM

This is a continuing program carried on by nutritionists, biochemists and animal husbandmen on basic and applied problems related to feeding and management of cattle for beef. The work is in progress at Beltsville, Maryland; in cooperation with State Experiment Stations at federally owned stations in Miles City, Mont.; Fort Robinson, Nebr.; Fort Reno, Okla.; Jeanerette, La.; Brooksville, Fla.; and Front Royal, Va.; and in cooperation with State Experiment Stations at Tifton, Ga.; College Station, Tex.; and Newell, S. Dak.

The Federal scientific effort devoted to research in this area totals 12.2 professional man years. Of this number, 4.2 are devoted to digestion and metabolism; 1.4 to concentrate; 1.7 to forage preservation and utilization; .5 to nutrient requirements; 2.1 to range and pasture management; .8 to management practices; and 1.5 to program leadership.

There is one grant involving Public Law 480 funds with the Agricultural College in Poznan, Poland. The project is to determine the trace mineral content of forages as affected by stage of growth and methods of harvesting and storing. The project is to run five years (1963-1968) and is supported by \$47,311.66 equivalent in Polish zlotys.

There are contracts totaling \$251,754 with the Agricultural Experiment Stations at California, Kentucky, Florida, Wisconsin, and Nebraska. These projects are concerned with the methods of feed preparation and level of grain in the ration, the sites and amount of starch utilization in the ruminant digestive tract, ration components which control feed intake, graded levels of energy intake upon reproductive performance in beef cattle and management of males of beef and dairy breeding for beef production. These projects will run three to four years (1964-1967 or 1968), their basic purpose being to determine the potential for increased utilization of grains for beef production.

PROGRAM OF STATE EXPERIMENT STATIONS

The States have research in progress on the basic functions of the rumen, particularly the animal-feed interrelations which are responsible for bloat, efficient feed digestion, and the synthesis of essential nutrients. (Additional investigations of rumen function appear in problem area #1).

The basic requirements of beef cattle for specific nutrients, their metabolism, interactions and availability in feeds are receiving attention at a number of stations. Some of the topics being investigated are: (1) The requirements, metabolism, and interactions of the many major and trace nutrients. (2) The effect of feed additives or implants upon growth and feed efficiency. (3) The relation of nutrients to metabolic disorders. (4) The toxicity of molybdenum and fluorine. (5) The value of irradiated feeds and assimilation of fallout products. (6) The use of roughage concentrate ratios and chemical regulators for feed intake control. (7) The effect of physical form of the ration upon nutritional value. (8) A re-evaluation of the vitamin A requirements and factors affecting them made necessary by apparent deficiencies on rations with ample carotene based on earlier standards.

The efficiency of feed use is being improved through investigations of concentrate and forage feeding. The problems and advantages of all-concentrate or high-concentrate feeding have high priority at this time. The comparative values of various kinds and combinations of feeds and the effect of different physical forms (chopped, pelleted, etc.) are being studied. There is considerable emphasis on development of methods for evaluation of forage crops. Four cooperative regional research committees (NC-64, NE-24, S-45 and W-34) have all or a significant part of their project devoted to this evaluation.

Management problems are being investigated. The main topics are combinations of pasture and drylot feeding; maximum use of pasture throughout the season, especially extending the period by using late fall and early spring pasture crops; supplementation needed when low quality roughages are fed; and creep feeding vs. non-creep feeding of calves.

The State stations have 49.6 professional man years devoted to Beef Cattle Nutrition and Management.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Digestion techniques. In-vitro tests with rumen fluid indicated that glutamic acid did not alter the ammonia production from urea and that glutamic acid was slowly deaminated by rumen microorganisms. Metabolic studies with steers indicated that the addition of glutamic acid to the "urea-purified" ration did not improve nitrogen retention over the basal ration.

Glutamic acid addition resulted in a significant increase in the molar percentage of butyric and higher volatile fatty acids in the rumen liquor. Glutamic acid appeared to be inferior to acetic acid, on an equal carboxyl basis, in its ability to lower excessive ammonia production in the rumen. (AH d2-8, AH d2-14)

When steers were fed loose or pelleted natural and purified rations, salivary flow and buffering capacity of the saliva was significantly depressed due to feeding the purified rations. Pelletting both the natural and purified rations resulted in a significant depression in buffering capacity of the saliva. The weight of the rumen contents was significantly depressed due to pelletting the rations, indicating a faster rate of passage on the pelleted rations. Pelletting also resulted in a significant depression in crude fiber digestibility with both rations. Ruminal pH, molar percentage of acetic acid, and ruminal ammonia concentrations were significantly less on the purified rations while total concentration of the volatile fatty acids was greatest on the purified rations. (AH d2-8, AH d2-14)

Cr_2O_3 was used as a marker to estimate rate of passage of food residues through the digestive tract of (6 and 8 months) pregnant heifers assigned to four levels of feed intake (60, 80, 100, 150% of recommended levels). There appeared to be a faster rate of passage when the heifers were fed at the high levels of feed intake and an equal or slightly slower rate of passage during the later stage of gestation. (AH d2-11, AH d2-22)

2. Bloat in beef cattle. In a study designed to test the effects of the physical form of a bloat producing ration on performance and severity of bloat, average daily gains were increased and severity of bloat was decreased if steers were fed the ration with the alfalfa coarsely (1 1/2" screen) rather than finely ground (3/8" screen). Rolling rather than grinding the barley portion of the ration did not affect gains or the severity of bloat. (AH d2-13)

3. Urinary calculi. Cattle studies at College Station, Texas, in cooperation with Texas Agricultural Experiment Station indicated that the addition of ammonium chloride prevented the formation of urinary calculi when feeding a basal ration of high moisture sorghum heads regardless of the other supplements used. Dipotassium phosphate, injected vitamin A plus dipotassium phosphate or diethylstilbestrol, increased the incidence or quantity of calculi while synovex had little or no effect. A dicalcium supplemental phosphate reduced incidence and quantity and improved performance. (AH d2-31)

In an attempt to produce urinary calculi of the magnesium-phosphate type, varying levels of calcium, phosphorus, potassium, and sodium were fed to albino rats. A high incidence of calculi occurred when a diet containing .3% Ca, 1.20% P, .1% K, and .8% Na. Urolithiasis did not occur when the percentage of any mineral varied markedly from those given above. Some kidney damage was observed when the diet was low in calcium and high in phosphorus. (AH d2-31)

4. Pesticide residues. At Tifton, Ga., steers fed for 27 days on corn silage made from corn with no dimethoate, with 1.1 parts per million and with 6.7 parts per million dimethoate (field applications were 1 and 2 lb. per acre, respectively) showed no effects from consuming 50 lb. of the treated silage per steer per day. The dimethoate treated silage was as palatable as the untreated. Blood samples taken the day before the test and at 6-day intervals during the feeding period showed no difference in the blood cholinesterase activity. This test and the concurrent one with dairy cattle showed dimethoate to be a pesticide that was not harmful to beef and dairy animals when used on forage to be ensiled for feeding. (AH d2-32)

In-vitro tests subsequent to those reported previously have confirmed the opinion that rumen protozoa are useful as bio-assay tools for screening insecticides which are susceptible to microbial breakdown and may be used on forage and other cattle feed crops. (AH d2-32)

5. Microbiology of the rumen. Concentrated cellular preparations of I. prostoma were incubated for 4.5 hr. at 38° C. with 1.0 µc each of linoleic-1- C^{14} , containing 250 µg/ml. of dihydrostreptomycin sulfate. After incubation, linoleic-1- C^{14} activity was distributed as follows: sterol and sterol esters, 0.4%; triglycerides, 13.3%; diglycerides, 6.4%; monoglycerides, 8.8%; cephalins, 12.7%; lecithins, 56.6% and other lipids, 1.8%. Oleic-1- C^{14} activity was primarily concentrated in triglyceride (24.0%) and the lecithin phospholipids (47.7%). Stearic-1- C^{14} activity was concentrated primarily in the triglyceride component (61.1%). This information may be helpful in further understanding the protozoan's metabolic requirements for future axenic culture studies, and its role in lipid contribution to the ruminant host. (AH d2-26)

6. Anatomical and physiological factors affecting digestibility. Total daily salivary production ranged from 38 to 68 liters per day when steers were fed a ground and mixed Bermudagrass corn ration and ranged from 25 to 51 liters per day when alfalfa pellets were offered. Animal and ration differences were significant. The steers secreted significantly more saliva (3X) while eating than while resting. When not feeding, the rate of salivary secretion was relatively uniform throughout the day. (AH d2-8)

As determined by feeding calves per os and via abomasal fistulae, post ruminal fiber utilization was about 25% less than when exposed to digestive action in the rumen. (AH d2-8)

B. Concentrates

1. High concentrate rations for finishing steers. Yearling steers fed an all concentrate ration based upon ground shelled corn and urea gained more rapidly when implanted with 24 mg. of stilbestrol. Gains were not improved when the ration was fed as a pellet or with a magnesium zinc supplement. However, feeding the pelleted ration resulted in steers with more fat over the rib eye, darker ruminal epithelium and higher ruminal ammonia concentrations. (AH d2-14)

At Fort Reno, Okla., fine grinding of milo resulted in a 5.2% improvement in feed efficiency compared to coarse grinding. Rate of gain was nearly the same. The use of finely ground milo (1/8" screen) in fattening beef cattle rations should be considered, especially in high roughage rations. It may be less desirable in high concentrate rations. For example, if molasses or fat is not used, a coarsely ground or rolled milo may be most desirable due to the dustiness of the finely ground milo. (AH d2-28)

All-barley rations supplemented with soybean meal, calcium, and vitamin A were fortified with trace minerals. There was an improvement in feed intake, body weight gains, feed efficiency, carcass grades - especially with supplementation of cobalt, zinc and iron. Dehydrated alfalfa meal and molasses appeared to offer no advantage other than as a source of trace minerals. The need to fortify all-concentrate diets with trace minerals is indicated. (AH d2-28)

Three rations containing 65, 80, and 95% concentrates were evaluated by finishing steers to market weights in studies at South Dakota. Feed costs per pound of gain were similar among the different treatment groups. The most efficient gains and the best carcass grades were obtained on a ration containing 80% concentrate and 20% roughage. Steers from the lower levels of concentrate had meatier carcasses yielding a larger percent of boneless trim retail cuts.

Short yearling steers were finished during the summer on a ration consisting of ground mixed alfalfa prairie hay, 20% and rolled barley, 80%. One group was full-fed and the other fed 85% of the amount consumed by the full-fed steers. Full-fed steers required less feed per pound of gain and made slightly cheaper gains, and averaged slightly higher in carcass grades. (AH d2-35)

Weanling steers supplemented with 5 lb. of rolled barley per day gained 1.54 lb. per head daily while those fed no grain averaged .98 lb. per head daily. The type of roughage (hay or silage) fed had no influence on the average daily gains. There was no significant differences in cost per lb. of gain.

In both yearling and steer calf groups, lots receiving long hay in addition to a ground and mixed ration consumed more total feed and gained faster (16%) but did not make more efficient gains. There were no differences in slaughter or carcass grades.

Rations containing about 70, 63, and 52% concentrates with or without coastal Bermudagrass hay were fed to steers at Tifton, Ga. Feed consumption increased as level of concentrates decreased. Gains were greatest for steers consuming the medium level of concentrates but overall steer performance was similar for the medium and high concentrate levels. There was no advantage to offering unground hay. Steers offered such rations can be placed on full feed the first day.

Low groups of 10 steers each were fed grain to roughage ratios of 9:1, 8:2, 7:3, and 6:4, respectively. The grain mixture was cracked shelled corn and fortified protein supplement. The roughage was coastal Bermudagrass hay. Daily gains decreased as the proportion of concentrate in the ration decreased. There was little difference in carcass grades or dressing percent between groups. Steers fed the highest concentrate to roughage ration were considered to be the most profitable. (AH d2-14)

C. Forage Preservation and Utilization

1. Utilization of coastal Bermudagrass. Six systems of utilizing coastal Bermudagrass were evaluated in steer feeding and pasture trials at Tifton, Ga. The average daily gains for the various systems were: 1.25 lb., continuous grazing; .93 lb., rotational grazing; .98 strip grazing; 1.94 lb., feeding pellets; 1.61 lb., feeding dehydrated hay; and 1.01 feeding fresh chopped grass. In general, feed consumption figures (where available) are correlated with gains. (AH d2-3)

From steer feeding tests at Tifton, Ga., it was concluded that dehydrated and suncured Bermudagrass pellets were equivalent in feeding value when offered in a 30 or 60% Bermudagrass ration. Steers receiving the 30% Bermudagrass ration (more corn) made faster and more efficient gains. (AH d2-28)

During a 75-day feeding period, steer calves gained about twice as fast on "poor" quality Pensacola Bahiagrass hay as when fed coastal Bermudagrass hay (.89 vs. .41 lb.). Steers fed good quality Bahiagrass gained 1.05 lb. per day. Chemical analyses revealed little differences among the hays. (AH d2-3)

2. Feeding value of pelleted feeds. At Beltsville, behavior studies have shown that more time was spent at the feeder when the steers were penned individually as compared to when penned by pairs. Feed consumption increased slightly and there was a significant increase in the speed with which the feed was consumed when the steers were penned by pairs. Time of day, form of feed and body weight relationship to feeding behavior patterns were the same as reported previously. It also appears that environmental temperature may be related to feeding behavior. Preliminary studies suggest that cattle feeding patterns are directly related to light dark cycles. (AH d2-28)

Acid detergent fiber (ADF) of a legume (alfalfa) and a grass (timothy) is being studied in a metabolism trial designed to determine if there is a forage species difference or an effect of the form in which the forage is fed (pelleted or ground) that may be related to the use of ADF as an indicator of digestibility. (AH d2-28, AH d2-14)

D. Range and Pasture Management

1. Range supplementation studies. At Brooksville, Fla., cows fed a year-round daily supplement of 5 lb. of blackstrap molasses with added urea (15% protein equivalent) were compared with cows which received the molasses-

urea mixture free choice during the winter. Calf performance to weaning showed no essential difference between the groups; however, the slight difference was in favor of the winter feeding of the cows. (AH d3-2)

Range management studies (Miles City, Mont.) have indicated that both cow and calf gains during the spring period were higher on the introduced grass pastures of crested wheatgrass and Russian wild-rye. Calf gains were similar on the introduced grasses. It will not be known until fall (1964) if the advantage in spring gains will carry over until weaning. The calving percentage of 94.6% was considered very satisfactory since no winter supplemental feed was provided and only a small amount of 2-year-old grass hay was fed during calving. It was concluded that optimum calving performance from range cows can be obtained if the range is kept in good condition. (AH d3-1)

At Tifton, Ga., average birth weights and weaning weights of calves were greater (62.4 vs. 81.4 lb. and 448 vs. 500 lb.) when the cows were pastured on burned range only in the spring and improved pasture only in the summer as compared to when pastured on unburned range and 0.6 acre improved pasture per cow in the spring and summer. (AH d3-3)

Studies on pasture and timber integration resulted in average liveweight gains per acre of pasture of 220, 219, 194, and 147 lb. for Bahiagrass, coastal Bermudagrass, Dallisgrass and Carpet grass pastures, respectively. Based on tree spacings, the liveweight gains were 248 lb. for no trees, 190 lb. for 20 x 20 tree spacings and 177 lb. for 12 x 12 spacings. (AH d3-4)

A cooperative experiment is now in progress where sheep, cattle and cattle plus sheep (1:5 or 1:1) are grazed at two stocking rates. The preliminary data suggests that there may be higher gains and more meat produced per acre when the two species are grazed together in a 1:5 ratio. (AH b3-10)(also see area 15-C-1)

E. Management Practices

1. Management of cattle and pastures for beef production. Graded levels of thyroprotein (0 to 15 1/2 g./day) were fed to intact and ovariectomized heifers at Fort Robinson, Nebr. Gains decreased as thyroprotein intakes increased and the intact heifers gained more than the ovariectomized heifers at all treatment levels. (AH d2-21)

At Fort Reno, Okla., grass hay, sorghum silage, and corn silage were fed to weanling heifers (for a period of 105 days). The weanling heifers gained uniformly during the feeding test and the condition and grades at the end of the trial were similar. More sorghum silage than corn silage was required for weanling heifers to make similar gains. Condition scores of the heifers were practically identical and there were no significant differences among the three treatments. (AH d2-34)

Hereford heifers were used to reflect the change in major tissue growth and development from 9 to 18 months of age. Bone made only a small change, while lean increased from 71 to 124 lb. Fat increased rapidly throughout the fattening period.

Expressed in terms of percent, lean and bone in the carcass decreased while fat increased. The percent lean in a carcass from animals slaughtered at 18 months of age was about 10% less than at 9 months. Fat increased by 12.3% and bone decreased by 2.4%. (AH d3-7)

The trace element study of soils and forages in Poland shows that there is a wide range in the mineral composition of soils of the experimental plots and significant differences between samples taken at different soil levels. (E21-AH-6)

Two trials (Fort Reno, Okla.) were conducted to study the effects of varying the level of winter feed and varying this level from low to high and vice versa during the first winter as weaner calves or the second winter as bred yearlings on subsequent performance of replacement beef females. In one trial, all the heifers were continued on the moderate level for the second calf crop.

The results show that the main effect of the first winter at a low level is to delay the onset of puberty and, as a result, delay conception and average calving data as two-year-olds. Other than this, the effects on growth and later performance appear negligible, providing good pasture and adequate feed levels are provided thereafter. There appears to be no permanent effect of a low level during one winter as a calf.

Of the two winter periods, low level feeding the second winter as a bred yearling appears to be most damaging. Here the heifer, while still continuing to grow and develop, must undergo the strain of calving and early lactation on inadequate feed supplies. The results are to delay re-breeding for the second calf, and a sharp reduction in milk flow. Naturally, this reduces the weaning weight of the calf.

Neither the low-high nor high-low sequence appears to be as beneficial as an adequate feed level (moderate) each winter in terms of growth and reproductive performance. (AH d2-36)

Eighty bred yearling Hereford heifers were fed four different levels of winter supplemental feed (milo and cottonseed meal) while grazing dry native grass pastures. Two groups were fed at a low level prior to calving and two groups were fed at a high level prior to calving. The heifers of one group on each level were switched to the opposite feed level at calving time. Thus, the four treatments were: low-low, low-high, high-low, and high-high, indicating, respectively, the feed levels before and after calving. The low level was the amount of feed necessary to establish a loss of more than 20% of the fall weight through calving. The high level was the amount necessary to maintain the fall weight through calving.

Heifers fed at the high level prior to calving dropped calves that averaged 14 lb. heavier at birth than did the low level heifers. Heifers fed high prior to calving returned to heat earlier, bred back earlier and had a high conception rate (93% and 100% vs. 53% and 75%) than did heifers fed low up to calving. Raising the low level heifers to high at calving resulted in a 2-week earlier breeding date, a high conception rate (75% vs. 53%) and an 18 lb. heavier average weaning weight. Average weaning weights followed amount of winter feed fed and were as follows: high-high, 432 lb.; high-low, 408 lb.; low-high, 376 lb.; and low-low, 358 lb. The heifers of the high-high lot had the highest average milk production, the heifers of the low-low lot had the lowest and the other two lots were intermediate between the two extremes. (AH d2-12)

2. Beef production from beef, dual purpose, and dairy steers. In a cooperative experiment, Holstein steers outgained Jersey and Hereford steers at all feeding levels studied. When placed on a higher feeding level, all steers that were started on a lower level of feeding gained more rapidly and more efficiently than steers that were liberally fed initially. Tenderness and palatability of the meat, and fat and lean content were related to the feeding regimens just prior to slaughter. (AH d3-6)(also see Area 5-C-5)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Digestion and Metabolism

- Dolnick, E. H., Cabell, C. A., Robbins, J. D., and Oltjen, R. R. 1963. Hair growth pattern in the rat as influenced by diets low in potassium. Proc. XVI Int. Congr. Zool., Washington, D. C., Aug. 20-27. (Abst.) (AH d2-31)
- Putnam, P. A. 1964. Beef Cattle : feeds and feeding behavior. Proc. Md. Nutr. Conf., March 12-13, p 10. (AH d2-28)
- Putnam, P. A., Cisar, M., and Davis, R. E. 1964. Growth and nitrogen balance with steers fed Hi-N-Molasses. J. Animal Sci. 23(2): 339. (AH d2-14)
- Putnam, P. A., Lehmann, R., and Davis, R. E. 1964. Rate of feed consumption and body weight of beef cattle. J. Animal Sci. 23(2): 425. (AH d2-28)
- Williams, P. P., and Davis, R. E. 1964. Lipid formation in Isotricha prostoma by incorporation of radioactive C-18 aliphatic compounds. Bacteriol. Proc. A55. (Abs.) (AH d2-26)
- Williams, P. P., Robbins, J. D., Gutierrez, J., and Davis, R. E. 1963. Rumen bacterial and protozoal responses to insecticide substrates. Appl. Micro. 11(6): 517. (AH d2-32)

Concentrates

- Davis, R. E., Oltjen, R. R., and Bond, J. 1963. High concentrate studies with beef cattle. J. Animal Sci. 22: 640. (AH d2-14)
- McCormick, W. C., and Southwell, B. L. 1964. A study of grain-roughage ratios for fattening steers. Prog. Rpt. 1963-64 (Tifton), pp 102-106. (AH d2-14)
- Oltjen, R. R., and Davis, R. E. 1963. Zinc, urea, and buffers in all-concentrate steer rations. J. Animal Sci. 22: 842. (Abs.) (AH d2-14)
- Renbarger, R., Pope, L. S., and Waller, G. 1964. Trace mineral supplements to "all-barley" rations for fattening steers. Prog. Rpt. 1963-64 (Fort Reno) pp 68-72. (AH d2-28)
- Southwell, B. L., and McCormick, W. C. 1964. The value of long hay in an all ground steer fattening ration. Prog. Rpt. 1963-64 (Tifton), pp 107-109. (AH d2-28)
- Southwell, B. L., McCormick, W. C. and Hale, O. M. 1964. Concentrate-roughage ratios in steer fattening rations. Prog. Rpt. 1963-64 (Tifton) pp 96-101. (AH d2-14)
- Totusek, R., Stephens, D. and Walters, L. 1964. Improving the utilization of milo for fattening calves : value of fine grinding and supplemental vitamins. Prog. Rpt. 1963-64 (Fort Reno) pp 63-67. (AH d2-28)

Forage Preservation and Utilization

- McCormick, W. C., Marchant, W. H., and Southwell, B. L. 1964. Coastal bermuda vs. Pensacola bahiagrass hays for wintering beef steers. Prog. Rpt. 1963-64 (Tifton) pp 64-66. (AH d2-3)
- McCormick, W. C., and Southwell, B. L. 1964. Dehydrated vs. suncured coastal bermudagrass pellets for fattening steers. Prog. Rpt. 1963-64 (Tifton) pp 91-95. (AH d2-28)
- Southwell, B. L. 1964. Coastal bermudagrass utilization study. Prog. Rpt. 1963-64 (Tifton) pp 77-81. (AH d2-3)

Management

- Bond, J., Hooven, N. W., Thornton, J., Hiner, R. L., and Warwick, E. J. 1963. Influence of breed and plane of nutrition on beef production from dairy, dual purpose and beef steers. Presented at a symposium on "Beef Production From Dairy Cattle," Rome, Italy. (AH d3-6)

- Hooven, N. W., Bond, J., Warwick, E. J., and Hiner, R. L. 1964. Influence of breed and plane of nutrition on the performance of dairy-dual purpose, and beef steers from birth to 180 days of age. J. Dairy Sci. 47: 690 (Abs.) (AH d3-6)
- Malkus, L. A., and Henrickson, R. L. 1964. Growth and development of beef heifers from weaning to 18 months of age. Prog. Rpt. 1963-64 (Fort Reno) pp 18-22. (AH d3-7)
- Smithson, L., Ewing, S. A., Renbarger, R. E., and Pope, L. S. 1964. Effect of high and low winter feed levels in alternate years on growth and development of beef heifers. Prog. Rpt. 1963-64 (Fort Reno) pp 78-83. (AH d2-36)
- Southwell, B. L. 1964. Herd management studies. Prog. Rpt. 1963-64 (Tifton) pp 113-123. (AH d3-3)
- Southwell, B. L., and Hughes, R. H. 1964. Integration of livestock and timber on intensively managed pastures. Prog. Rpt. 1963-64 (Tifton) pp 124-132. (AH d3-4)
- Turman, E. J., Smithson, L., Pope, L. S., Renbarger, R. E., and Stephens, D. F. 1964. Effect of feed level before and after calving on the performance of two-year-old heifers. Prog. Rpt. 1963-64 (Fort Reno) pp 10-17. (Ah d2-36)

AREA NO. 5: DAIRY CATTLE - BREEDING

Problem. Dairymen need information on genetic methods for increasing the efficiency of milk production and modifying milk composition, as well as other economic traits, in order to reduce unit costs and meet the future market demands. Precise information is needed on the relative importance of performance traits, the nature of their inheritance and their response to selection and specific systems of mating. Advanced genetic methods, such as those utilizing heterosis and specific and general combining ability, need to be evaluated as procedures for more rapid improvement of milk production or other important traits.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by geneticists on basic and applied studies of the inheritance of the dairy cow, including experiments designed for evaluating the application of advanced genetic concepts to dairy cattle improvement. The work is in progress at Beltsville, Maryland, and cooperatively with 14 State experiment stations and laboratories in nine foreign countries. Several of the studies contribute to the North Central and Southern regional dairy cattle breeding projects. Cooperation is also carried out with the National Association of Artificial Breeders and with the various dairy cattle breed registry organizations.

The Federal scientific effort devoted to the research in this area totals 18.2 professional man-years. Of this number, 6.0 are devoted to genetics and interrelations of performance traits, 11.0 to selection and systems of breeding, and 1.2 to program leadership.

A grant with the Agricultural Research Center, Tikkurila, Finland, provides for research on the breed differences regarding the antigenic properties of cattle blood, their inheritance in relation to economic characteristics and genetic origin of the breeds. Its duration is for four years, 1961-64, and involves PL-480 funds with a \$61,804 equivalent in Finnish Finmarks.

Another grant with the Division of Investigaciones Agropecuarias, Ministry of Agriculture, Bogota, Colombia, supports work on the evaluation of the native breed, Costeno Con Cuernos, and Holsteins and Brown Swiss when mated and selected for dairy traits under the hot and humid conditions of Northern Colombia. The duration of the grant is for five years, 1962-67, and involves PL-480 funds with a \$246,000 equivalent in Colombian pesos.

Two PL-480 projects (also reported in area 6) S3 AH-7, at Sao Paulo, Brazil, and A7 AH-1, at Izatnagar V.P., India, are in effect and are pertinent to this area.

A contract in the amount of \$20,000 per year is in effect with the Wisconsin Agricultural Experiment Station to study the meat production potential of dairy cattle. Its duration is four years.

PROGRAM OF STATE EXPERIMENT STATIONS

Dairy cattle breeding research is conducted with experiment station and college herds, institutional herds, and privately owned herds; with data available through the DHIA program; and in cooperation with artificial breeding associations in sire proving and similar studies. Areas of investigations include: (1) the estimation of genetic parameters such as heritability, genetic correlations, genetic transmitting ability, and heterosis, and (2) response to programs for genetic improvement. Specific items of study include selection response, milk constituents, crossbreeding, genetic abnormalities, climatic adaptability, blood antigens, milking rate, and efficiency of feed utilization. Much of the research is conducted under two regional projects-- NC-2, Improvement of Dairy Cattle Through Breeding, and S-49, Genetic Methods of Improving Dairy Cattle for the South.

The USDA is cooperating on several research projects with the State agricultural experiment stations and participates actively in the two regional projects.

The total research effort on dairy cattle breeding research by the State agricultural experiment stations is 46.8 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Genetic-environmental interactions in feeding efficiency and consumption. At Lewisburg, Tennessee, a total of 154 first lactation Jersey cows by 11 sires have completed 305 day production records; 77 on roughage only and 77 on roughage plus grain. The average mature equivalent fat corrected milk (ME FCM) yield for the roughage only group was 9,702 pounds as compared to 12,196 pounds for the roughage plus grain group. The roughage only group produced 79.6% as much ME FCM as the roughage plus grain group. The individual sire groups ranged from 68.4 to 83.4%.

Highly significant differences between rations were found for ME milk, ME fat and ME - FCM production. There were also highly significant differences between sires within ration groups for these measurements. The sire X ration interaction was not significant for any of the measures of production. In the no grain group, it was shown that there were differences between sires in the ability of their daughters to consume roughage. This between sire difference in roughage consumption was in the form of both silage and hay. These preliminary results indicate that there is no interaction between sires and rations, but there are differences in the ability of daughters of

different sires to consume forage.

At Utah a total of 112 first lactation Holsteins by 10 sires have finished production records, 52 on forage only and 60 on forage plus grain. Six of the sire groups originated at the Huntley, Montana Station and, 4 sire groups originated at the Utah Station. The average ME FCM yield of the cows fed hay only was 9,584 pounds as compared to 13,664 for the cows fed grain and forage. The range in ME FCM production for the hay only group was from 7,595 to 10,981 pounds, whereas the range for the forage plus grain group was 10,765 to 15,391 pounds. The hay only groups produced 67.2% as much as their half-sibs on forage plus grain. The individual sire groups ranged from 54.8% to 76.8%. An analysis of variance using weighted means indicated significant differences among sires and rations. However, the sire X ration interaction was not significant. The results paralleled those reported from the Jersey data at the Lewisburg, Tennessee station. The most striking difference between the two studies was the higher ME FCM yield of the Jerseys on the all forage ration. The Jerseys on forage only produced 9,702 pounds as compared to 9,584 pounds on the Holsteins at Utah. These results indicate that Jerseys are considerably more efficient than Holsteins in utilizing forage for milk production. (AH gl-4)

2. Ration effects on production efficiency. The research at Beltsville to determine the value of certain feeding regimes in estimating genetic differences in feed efficiency among cows is now completed. The detailed analysis of the data is not completed; however, preliminary results are available on 43 completed lactations from a total of 25 cows fed at a constant rate of feed intake. Their average FCM yield was 13,977 pounds with a feed efficiency index of 1.999. The corresponding standard deviations were 2,022 and 0.27, respectively. Twenty seven cows fed according to production and maintenance requirements have completed 45 lactations. These cows averaged 15,039 pounds of FCM and their efficiency of feed utilization was 1.944. The standard deviation of FCM yield and feed efficiency was 2,626 and 0.194, respectively. The greater yield of 1,062 pounds from the groups fed according to requirements was probably due in part to differences in energy intake. This group consumed an average of 753 therms of additional energy. This would be expected when feed intake is varied with production and maintenance requirement as opposed to feeding at a constant level of energy intake regardless of requirements. The repeatability between successive lactations for FCM yield was 0.378 and 0.623 for the constant fed and requirement fed groups, respectively. The repeatability of feed efficiency was 0.283 and 0.511 for the constant fed and requirement fed group, respectively. The requirement fed group was more persistent and gained more weight during the lactation than the constant fed group. (AH gl-4)

3. Genetic parameters of feed efficiency. A statistical study was made using Beltsville Holstein data to determine heritability of feed efficiency and genetic correlations between efficiency and production. There were 684 lactations by 332 individual cows, which represented 27 sire groups and

included 255 daughter-dam pairs. The means for FCM yield, therms intake and gross feed efficiency after corrections were made for environmental influences were 11,380, 6,520 and 1.74; 13,810, 7,860 and 1.76; 15,360, 8,430 and 1.83; 15,870, 8,760 and 1.81; 16,360, 8,620 and 1.89 for the first, second, third, fourth and fifth lactations, respectively. The increase in gross efficiency as the lactation number increased is probably a reflection of the animal's decreasing need for energy to increase body size. Therefore, a proportionately greater amount of energy is being used for production as the lactation number increases.

The within sire phenotypic correlations for all lactations between FCM yield and feed efficiency, FCM yield and therms intake, and therms intake and feed efficiency were 0.86, 0.74, and 0.31, respectively. These were all significant at the 1% level of probability.

Utilizing the data on 255 daughter-dam pairs over all lactations the genetic correlations between FCM yield and gross efficiency, FCM yield and therms intake, and therms intake and feed efficiency were 0.92, 0.82, and 0.52, respectively. These were all significant at the 1% level of probability. The genetic correlation between FCM yield and feed efficiency of 0.92 indicates that selection for FCM yield would also bring about increased efficiency of feed utilization. The estimates of heritability were 0.52, 0.43 and 0.52 for FCM yield, therms intake and feed efficiency, respectively, on all lactations combined.

Significant sire differences were found for FCM yield, therms intake, and feed efficiency on a first and combined lactation basis.

From these studies it is evident that gross feed efficiency is a heritable trait, and could be increased by selecting directly for it. However, because of the high genetic relationship with production little would be gained by including it in a selection program.

A second objective of this study was to determine if feed efficiency could be estimated from a shorter period of time than a complete lactation. The data in this phase of the study included 525 lactations on 311 cows by 18 sire groups. The feed consumption and FCM production were summarized by 10 day periods for each lactation. The analysis showed a correlation of 0.88 between feed efficiency for the period 121 - 180 days and total lactation. The correlation for the second 100 days of lactation and total lactation was 0.92. These results indicate that feed efficiency can be estimated from relatively short periods of time. (AH gl-4)

4. Relationships between milk yields and rate of milking. Individual quarter milking rate data were collected on 77 Holstein and 42 Jersey cows during second or later lactations. Highly significant differences were found among cows, among quarters of the udder and between morning and evening milking after 15 and 9 hour intervals for total yield per quarter, volume of milk obtained to a minimum rate of .4 lb./min., length of this

portion of the milking and maximum rate of flow. Correlations with total milk were 0.96 for volume of milk to a rate of .4 lb./min., 0.80 for duration of time at this rate and 0.83 for maximum rate. Breed group differences were also significant for the three variables measured. When cows were divided into high and low production groups, differences occurred between them for yield to a rate of .4 lb./min., length of time to .4 lb./min. and maximum rate. When the data were adjusted to a common production level these differences disappeared. No evidence for age effects were found. (AH g1-2)

5. Meat production from beef, dual purpose and dairy steers. This study was initiated in cooperation with the Beef Cattle Research Branch to determine the relative merits of various breeds of cattle and different management systems in the production of meat. The first phase of the second replication of this study is completed. Holsteins, Milking Shorthorns, Jerseys, and Hereford steers were fed during the first 6 months of life either on a high plane of nutrition involving large quantities of whole milk or a low plane of nutrition typical of dairy replacement feeding practice to 6 months of age.

The average daily rate of gain for the high plane group was 2.69, 2.34, 1.95, and 1.79 for the Holsteins, Milking Shorthorns, Herefords, and Jerseys, respectively. Feed efficiency was 0.38, 0.36, 0.32, 0.33 for the Holsteins, Milking Shorthorns, Herefords, and Jerseys, respectively. In the low plane group the average daily rate of gain was 1.28, 1.35, 1.26, and 1.19 for the Holsteins, Milking Shorthorns, Herefords, and Jerseys, respectively. Feed efficiency for this group was 0.38, 0.36, 0.35 and 0.35 for the Holsteins, Milking Shorthorns, Herefords, and Jerseys, respectively. Analysis of variance showed that both breed and treatment differences were significant for average daily rate of gain. However, in feed efficiency only breed differences were significant. As compared to the first replication, the average daily rate of gain increased by 30% for Holsteins, 44% for Milking Shorthorns, 40% for beef breeds, and 46% for Jerseys on the low plane of nutrition. This increase in gain corresponds to an overall average increase in energy intake of 43% between the two replications.

At 180 days of age 13 steers from the high plane group and 12 from the low plane group were slaughtered for carcass evaluations. The average percentage of lean, fat, and bone was 59.1, 19.7, and 21.2 for the high plane group. In the low plane group the corresponding percentages were 62.9, 11.3 and 25.7, respectively. The lean from the 9 - 11 ribs of the high plane steers were significantly more tender as evaluated both by the Warner Bratzler shear and a panel of judges. These results are similar to those obtained in the first replication. (AH d3-6)

6. The genetics of blood antigens in dairy cattle. Blood group specificity is a consequence of the chemical structure of the erythrocyte stroma. Specificity is retained even after ether extraction followed by alkaline aqueous washing. At the Ohio laboratory, material produced by this process

was treated with papain. The papain resistant, insoluble residue had only F specificity when tested in inhibition tests. After suitable preparation the soluble portion was passed through a Sephadex G-25 column. Fluant fractions showed two carbohydrate peaks. Material from the first, which coincided with a protein peak, specifically inhibited V blood group factor activity when the substrate was from V-positive cells. No inhibition occurred when V-negative cells were used. Neuraminidase treatment of stroma eliminated F activity but had no effect on V activity. Sialic acid released by the neuraminidase was not effective in inhibiting F reagent even though a concurrent loss of F activity occurred in the sample treated with the enzyme. Two commercial sialic acid derivations, N-acetyl neuraminic acid and N-glycolyneuraminic acid, also proved ineffective in inhibition tests. (AH gl-6)

The PL-480 project in Finland is now in its fourth and final year. The Finnish laboratory has produced 41 blood typing reagents. Two of these, SF-1 and SF-4, are new reagents in the B-system. Another, SF-3, still appears to be unrelated to any of the known bovine blood group systems.

Studies of three cow families failed to indicate any relationship between the inherited polled condition and blood groups. Preliminary studies also failed to indicate relationship between blood groups and congenital hydrops.

Blood group studies of 1,364 dam-daughter combinations (A.I. sires) indicated that 4.33% of the pedigrees were in error on the base of this comparison alone. Sires of dams were in error in 3.01% of the cases so over 7% of the pedigrees were erroneous in the first two generations. These figures compare well with data from other countries.

Analyses of 454 disputed parentage cases (two possible sires) resulted in a solution by blood grouping in 83% of them. When cows were bred to two different bulls during the same estrus period the last sire used was found to be the sire of the calf in about 70% of the cases. This finding is in agreement with the recommendation that cows should be inseminated late in estrus. (PL-480-E8-AH-1)

7. Genetics of milk constituents. The national cooperative effort to obtain data on milk, milk fat, solids-not-fat and protein production of individual cows is continuing. Preliminary analysis of data is in progress at Virginia Polytechnic Institute under the direction of the Interregional Research Committee on Milk Composition. Lactation records numbering 10,361 have been contributed by Northeastern, Southern and North Central Cooperators. The number of lactations by breeds are as follows: Ayrshire 385, Guernsey 1,114, Holstein 5,685, Jersey 2,757, and Brown Swiss 420. The Beltsville contribution to data is 440 lactation records. One preliminary finding is that milk, fat, and solids-not-fat (SNF) yields exhibit a seasonal pattern with means for the periods of November-April and May-October differing significantly. The average milk, fat, and SNF yields were

12,970, 487, and 1,118 pounds for the winter period and 12,050, 454, and 1,045 pounds for the summer period. It is important to note, however, that no seasonal patterns were detected in the percentages of fat and SNF.

The Beltsville analysis is particularly concerned with the use of milk composition information to calculate energy output in the milk. Factors for the calorific value of milk fat, protein and lactose are available from the literature. These are being applied to the data obtained by rapid testing methods to arrive at a production figure for each cow in terms of therms of energy. Since the mineral portion of milk moves very little, it is possible to arrive at lactose percent by subtracting protein percent plus 0.7 (an average for mineral) from SNF percent. Forty-six samples of milk from individual cows were tested by rapid methods for fat, protein and SNF and the therms per pound calculated by the above approximation method. These values were compared with those obtained by bomb calorimetry tests on the same samples of milk. The average therms per pound in these samples was .291. The average difference between values obtained by the two methods, one an approximation and the other a direct tests, was .013 when sign of the difference was not considered. Considering sign the average difference was .006. The correlation between the two methods was .84. Although these are preliminary results it appears that a fair estimate of energy in milk can be made in the manner described above.

In a preliminary attempt to compare results, ten fresh milk samples were sent to laboratories in the North Eastern region. Eight laboratories tested the samples for butterfat by the Babcock method. The average differences from the true value for laboratories ranged from .07 to .20 when sign of difference was not considered. Six laboratories tested the samples for protein using a dye-binding method. The average differences for laboratories between Kjeldahl and dye-binding methods ranged from .048 to .14 (without sign). Five laboratories tested the samples for SNF by gravimetric drying methods and seven tested for SNF using a density method. Six laboratories used the Watson lactometer and one used Golding beads. One of the laboratories used both methods so eight sets of data were available. The average gravimetric value for each sample was taken as the best estimate of the true value and differences for the density methods were calculated as they were for fat and protein. The average differences for laboratories using the Watson method ranged from .105 to .284 (without sign). Corresponding averages for the two laboratories using Golding beads were .278 and .472. Although only a preliminary study, this experiment indicates a need for more work of this kind and focuses attention on certain laboratories that are having difficulty with particular methods. In general, the dye-binding test for protein appears to be more repeatable from laboratory to laboratory than does the density method for SNF.

Although cooperative work with the Eastern Utilization Division is continuing, milk protein typing is now being done at Beltsville for studies of association between these and other genetic polymorphisms and traits of

economic importance. Electrophoretic studies of milk from 165 cows provided further confirmation of the genetic control of variation in α_s and ρ casein and in β -lactoglobulin. The predominant types found continue to be the α_s -B and β -A types of casein. The A and B forms of β -lactoglobulin are found with approximately equal frequency. One use of genetic milk typing which has been demonstrated is in selecting identical twins. Out of ten pairs of twins which were presumed to be identical after blood typing, three were found to be non-identical on the basis of milk protein types. This is probably a much higher percentage of rejections than expected and is probably due to chance in this small sample. However, these findings emphasize how useful these additional genetic markers can be. (AH gl-5)

B. Selection and Systems of Breeding

1. Comparisons of inbreeding and outbreeding. The development of crosses among six inbred lines of Holstein-Friesian cattle and maintenance of controls has continued. Data were analyzed to estimate the effects due to system of mating and age and their interaction. Three of the lines showed similar results in that the interactions between mating system and age on all seven body measurements were not significant. Age effects were very similar between sire lines within each of the measurements. Although body measurements remained relatively constant from one age to another, there existed a great variation among the three sire lines. Inbred calves were generally smaller than non-inbreds. In the other three-sire-lines the results were different. Age trends in growth differed from one mating system to another. The maximum effects of inbreeding on growth seemed to be between 6 and 12 months of age. At older ages, inbreeding accounted for decreasing proportion of the total variation.

Mating system was significant for all body measurements after calving in two lines and most measurements in the other four lines. In general, inbreds were smaller than non-inbreds. In some cases, the outcrosses did not exceed the inbreds of the same sire-line. Lack of significant interaction between mating system and parity were considered as evidence that inbreds did not appear to grow more rapidly and thereby tend to approach the size of the non-inbreds for the period studied.

No interactions were found between mating system and lactation number of various production traits. The change in production with lactation number was the same for all mating systems. Generally, inbred cows produced less milk and fat than the non-inbreds of the same sire line. Inbred cows tended to be older in age at each calving than the outcrosses and line crosses. The differences varied from sire-line to sire-line.

Analysis of 3,076 ovulations covering 728 cow parities revealed the incidence of quiet ovulations to be 23.7%. Both sire-line and season had significant influences on the rate of quiet ovulations. A higher incidence (25.8 vs. 21.5) of quiet ovulations occurred from March 1 to August 31

than from September 1 to February 28. Influence of system of mating was found to be nonsignificant, but its interactions with line and with parity were significant. A highly significant negative correlation between incidence of quiet ovulations and interval since calving in cows or 12 months of age in heifers was noted. A low but highly significant repeatability (0.04) within parity also was found.

A total of 790 parities (728 non-cystic and 62 cystic) covering 3,549 ovulations was analyzed for effects of sire-line, system of mating, parity, cystic condition, and individuality of the cow on the incidence of multiple ovulations. Sire-line had no significant influence. Frequency of multiple ovulations increased in association with the cystic condition (noncystic 4.2, cystic 12.9%) and with increasing parity (2.9, 3.7 and 5.9% for parities one through three). Outbreds had a significant higher incidence of multiple ovulations than inbreds (outbreds 5.2, inbreds 3.2%). A highly significant repeatability (0.07) within a cow also was noted. (AH g2-5)

2. The relative importance of general and specific combining ability in breeding dairy cattle. Inbreeding effects on growth were studied on 2000 females. Four measures of size at ages 3, 6, and 12 months, 3 months after first calving and 3 months after calving at mature age were included in the analysis. Significant negative regressions of inbreeding on heart girth and wither height were found for all ages except maturity. In chest depth all ages were significant. The regressions for body length were significant for 6 months, 12 months and three months after first calving. These results indicate that even at low levels of inbreeding, economic characteristics are depressed.

Over a period of 10 years, 395 pregnant females returned to estrus one or more times during the pregnant period and were bred either naturally or artificially. Heifers appear to return to estrus more frequently in the later stages of pregnancy than older cows. There was a significant decrease in fertility for the animals which were in estrus during pregnancy, for the breeding period following the gestation with estrus. (AH g2-22)

3. The influence of parental relationship on the genetic merit of dairy cows and sires. This research was undertaken to determine the relative merits of line-breeding, outcrossing and crossbreeding using progeny tested bulls of high merit as service sires. The actual first lactation FCM averages for the various groups are as follows: thirty-seven linebreds, 11,455 pounds, thirty-nine outcrosses, 11,380 pounds and thirty-nine crossbreds, 10,993 pounds. These differences are not significant.

Heifers from each mating system were placed on a standardized ration of free choice alfalfa hay and three pounds of grain per day for 120 days between the ages of 12 to 16 months. Analysis of variance indicated significant differences among groups and among sires within groups for therms of energy consumed in hay and average rate of gain over the experimental period. The

outcrosses gained the most rapidly followed by linebreds, Swiss-Holstein crosses and Ayrshire-Holstein crosses. There were no differences among groups or among sires within groups in efficiency of feed utilization.

A second objective of this study was to determine relationships between growth and efficiency as heifers and production and efficiency as cows. A significant negative correlation was found between therms of energy consumed during the 120 days growing period and fat corrected milk yield for the Swiss-Holstein crosses. Although not significant, the correlations between productive milk traits and growth traits were negative. These data suggest little relationship between growth characteristics and milk production traits. (AH g2-24)

4. Crossbreeding using artificial insemination. At Minnesota a study was conducted to determine the value of crossing breeds using sires as they are available in A.I. In two State Institution owned herds of Holsteins a portion of their cows were mated to Brown Swiss bulls and comparisons were made between the resulting crossbreds and contemporary purebreds. In the Moose Lake herd 17 purebred first lactation heifers produced 10,436 pounds of FCM as compared to 10,345 pounds of FCM for the crossbreds. At Willmar, the purebreds produced 8,694 pounds of FCM as compared to 7,722 pounds FCM for the crossbreds. It is interesting to note the wide differences in results from the two herds. At Moose Lake the crosses were nearly equal to the purebreds while at Willmar the crosses were markedly inferior. The two herds are served by different artificial breeding organizations with different bulls. It appears that the organization serving the Moose Lake herd had Holstein and Brown Swiss bulls of about equal merit while the organization serving Willmar had better quality Holstein than Brown Swiss bulls. Results indicate that no advantage would be gained for dairymen with Holstein cattle to breed their cows to bulls of other breeds. (AH g2-26)

5. Usefulness of heterosis resulting from interbreed matings. An analysis of birth weights of calves born in generations 1, 2 and 3 (1/2, 3/4 and 5/8 of Holstein and Guernsey breeding) from the Illinois project showed that crossbreds were 3.2 lb. heavier than the average of the parental purebreds. For each increase of 1/8 Holstein breeding in the dam, the weight of the calf increased 2.03 lb., while the weight of the calf increased only 0.75 lb. for a comparable increase in the germ plasma of the sire. None of the crossbred groups were as heavy as the purebred Holsteins. There were considerable differences in birth weights associated with sex, parity and sires within breeds, but because of the disproportionate numbers in the breed groups, adjustments had little effect on the sub-class means.

There was an apparent maternal effect on birth weight and paternal effect on gestation period as the 5/8 Guernseys were as heavy at birth as the 5/8 Holsteins. It is likely that the maternal and paternal effects were the results of an interaction between birth weight and gestation periods. When a Guernsey sire was mated to a Holstein female the crossbred fetus had an inherent capacity for a lighter birth weight and a longer gestation period

than the purebred Holstein dam, thus at the time of parturition the fetus had been carried as long as if it were a purebred Guernsey and grown to almost the weight of a purebred Holstein. (AH g2-23 Rev.)

Data on purebred Red Danes, Red Polls, Milking Shorthorns and two- and three-breed crosses in the Indiana project were analyzed for the effect of type of dam (purebred or crossbred), breed of dam, breed of sire, breed of dam by breed of sire interaction, sire within breed, year of calving, and season of calving on milk production, highest monthly milk yield, persistency during lactation and 30-day periods of production.

Highly significant effects were generally found for breed of dam, breed of sire, breed of dam by breed of sire interaction and sire within breed. Significant effects were also generally found for type of dam and season of calving. Other effects were, in general, nonsignificant.

The results of the comparison of purebreds with two-breed crosses indicate heterotic effects for total milk and for yield during the first eight months of lactation, but this came mainly from crosses involving the Red Dane breed. Heterosis was found in all of the crossbreds except for persistency and the last 30-day period of production (10th month) in the case of the Red Dane x Milking Shorthorn crosses. In this study little additional superiority was obtained by crossing two-breed crosses to a third breed. The crosses having the Red Dane breed as one of the parents showed the largest degree of heterosis and they were also the highest groups for milk yield.

Specific combining ability - an estimate of how well specific breeds combine - was unimportant, but the effects from general combining ability - a measure of the overall efficiency with which various breeds combine - were highly significant. The Red Danes were the highest producing breed and had the highest general combining ability with the other breeds. (AH g2-23 Rev.)

A preliminary analysis of rate of gain at three month intervals from birth to 12 months of age for crosses among Ayrshires, Brown Swiss, and Holsteins at Beltsville indicate that the gain of two-breed crosses exceeded the parental mean by 6% during the first 3-month period. This was reduced to 2% during the next six months and the crosses did not exceed the parental mean during the 9 to 12 month period. The larger difference during the first three months was attributed to the slow start of the purebred Swiss. Gains of the crosses exceeded the expected to a significant degree (7%) from 12 months of age through the first lactation. The accelerated gains of the crosses and purebred Swiss at the later ages were due to fleshing rather than an increase in skeletal dimensions.

Studies of various phenotypic traits of body conformation showed that two-breed crosses tended to score higher in most traits than the parental mean. The crossbreds exceeded the parental mean to a significant degree in condition or body fleshing. Some characteristics, such as straightness of rear

legs, shape and attachment of udder, and teat placement were influenced more by crossing than others and breed of sire appeared more important than breed of dam in determining these phenotypic traits.

Thus far there has been no evidence of significant differences between purebreds and crossbreds in the number of services for conception, interval from calving to first estrus, interval from calving to first service, interval from first service to conception and mean calving interval, although the crossbreds were slightly superior in these traits. The crosses required 0.4 less services per conception, came in heat 9 days earlier after calving, conceived 5 days earlier, and had a 10 day shorter calving interval than purebreds. (AH g2-23 Rev.)

A preliminary analysis of production records of purebred Ayrshires, Brown Swiss, and Holsteins and two-breed crosses among the three breeds from the Beltsville project showed no significant difference between purebred Holsteins and Ayrshire x Holsteins and Brown Swiss x Holstein crosses in first lactation total milk, 4% FCM, solids-not-fat, and protein yields, or total therms produced. These two crossbred groups were significantly superior to the purebred Holsteins in milk fat production, body weight gain in lactation, and the number of days carried calf during lactation. The purebred Ayrshires, Brown Swiss, and the Ayrshire x Brown Swiss crosses were similar in milk, 4% FCM, and protein yields, and total therms produced, but were significantly below the other three groups for these traits. The purebred Brown Swiss and Ayrshire x Brown Swiss crosses were significantly higher than all other groups in body weight gains during first lactation. The purebred Ayrshires were lowest in persistency of milk yield, while the purebred Brown Swiss and Holstein x Brown Swiss crosses were highest. There was no significant difference among the six breed groups in gross efficiency (lb. FCM/therm estimated energy consumed) or in the ratio of total therms produced to total therms consumed although the Holstein crosses were slightly superior in these traits. These preliminary results indicate that half-Holstein crosses produce slightly more total energy during the first lactation and do so a little more efficiently than purebreds or Brown Swiss x Ayrshire crosses. (AH g2-23 Rev.)

An analysis of gestation length involving two and three breed crosses with Holsteins, Ayrshires, and Brown Swiss at Beltsville showed a significant maternal as well as paternal effect upon gestation length. The means for Holstein, Ayrshire, crossbred, and Brown Swiss dams were 280, 280, 282, and 285 days, respectively, while the means for Holstein, Ayrshire and Brown Swiss sires were 280, 281 and 285 days. The interaction between breed of sire and dams was also significant. Purebred Holsteins had an average gestation length of 277 days; purebred Ayrshires 279; and purebred Brown Swiss 288 days. Matings between Ayrshire sires and Holstein dams, or their reciprocals, resulted in a mean gestation length of 278 days. Ayrshire and Holstein sires mated with Brown Swiss dams resulted in a mean gestation length of 284 days. Brown Swiss sires mated with either Holstein or Ayrshire dams resulted in a mean gestation length of 285 days.

These results indicate that matings involving Brown Swiss blood caused an increased gestation length.

Similar results have been obtained in the Illinois study where Holsteins and Guernseys were crossed. The means for purebred Holsteins and Guernseys were 279 and 284 days, respectively. The Guernsey dams bred to both Guernsey and Holstein sires carried their calves an average of 283 days, whereas Holstein dams bred to both Guernsey and Holstein sires carried their crossbred calves for 281 days. Calves by Guernsey sires were carried 284 days as compared to 279 days for calves by Holstein sires.

The average gestation length for all crossbred calves at Beltsville and Illinois was the same as the parental mean, indicating that the portion of the breed involved in the mating largely determined the gestation length and that additive gene action, rather than heterosis, is involved.

(AH g2-23 Rev.)

Nine body measurements taken at 18, 24, 30, 36 and 48 months of age in the Illinois herd were used to determine the relationship of growth of purebreds and crossbreds to concurrent FCM production and pregnancy. The only significant effects of pregnancy on growth before 24 months were for heart girth and two length dimensions. Both lactation and pregnancy produced their largest effects on growth in the 24-30 month period. In this period all the significant regressions were negative. Fleshing measures (forechest circumference, depth and width) were most severely affected. After 30 months both factors produced fewer significant effects on growth, but lactation had the greater effect throughout. The growth of cows with crossbred dams was least affected by concurrent lactation and pregnancy. Both breed of sire and breed of dam had significant effects on skeletal growth but none of their interaction effects were significant. (AH g2-23 Rev.)

6. Genetic methods for developing adaptability. Phenotypic and genetic parameters were determined from 2,297 records of 615 daughters of 56 sires in the Louisiana State University herd. Intrasis regression estimates for the heritability of milk production per day of productive life, length of productive life, breeding efficiency and type were 0.28 ± 0.12 , 0.00 ± 0.09 , 0.07 ± 0.13 and 0.34 ± 0.16 , respectively. The paternal half-sib estimates were 0.49 ± 0.16 , 0.39 ± 0.14 , 0.11 ± 0.10 and 0.15 ± 0.14 . Significant ($P < .01$) phenotypic correlations were found between ME milk production per day of productive life and 2X-305 day ME first record (0.45), first record and breeding efficiency (-0.24), age at disposal and type (0.39), actual lifetime production and type (0.36), actual lifetime production and first record (0.29), age at disposal and first record (0.22) and length of productive life and first record (0.22). The estimates of heritability and the phenotypic correlations obtained are of comparable magnitude to those for the same traits in cooler climates indicating the expected changes from selection in warm climates is similar to that of cooler climates. (AH g4-2)

A study of 5 years of data on percent solids-not-fat (SNF) of purebred Holsteins, 1/2 Holstein crosses out of Jersey or Red Sindhi-Jersey crossbreds and 1/2 Brown Swiss crosses out of Jersey, Red Sindhi-Jersey crossbreds or Holstein dams in the herd at Jeanerette, Louisiana, showed the average for purebred Holsteins (8.29%) fell below the minimum requirement for most southern milk markets (8.50%); whereas the crossbred groups were well above, 8.72 and 9.00% for the Holstein and Swiss crosses, respectively. The orthogonal comparison of Holsteins vs both crosses and Holstein crosses vs Brown Swiss crosses were both highly significant ($P < .01$). The interaction of year-season with breed groups was nonsignificant. The difference in percent SNF between the two crossbred groups was primarily due to breed of sire since the mean SNF for dams of the crossbreds was about the same. The average percent fat was 3.52, 4.03 and 4.02 for the purebred Holsteins, Holstein crosses and Swiss crosses, respectively. The purebred Holsteins averaged 645 lb. milk more than the 1/2 Holstein crosses and 861 lb. more than the Swiss crosses. (AH g4-2)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Genetics and Interrelations of Performance Traits

Kiddy, C. A. 1963. Methods for solids-not-fat and protein determination. J. Dairy Sci. 46:1289-1293. (AH g1-5)

Kiddy, C. A. 1964. Inherited differences in specific blood and milk proteins in cattle. A review. J. Dairy Sci. 47:510-515. (AH g1-5)

Kiddy, C. A., Johnston, J. O. and Thompson, M. P. 1964. Genetic polymorphism in casein of cow's milk. I. Genetic control of α_s -casein variation. J. Dairy Sci. 47:147-151. (AH g1-5)

Thompson, M. P., Kiddy, C. A., Johnston, J. O. and Weinberg, R. M. 1964. Genetic polymorphism in caseins of cow's milk. II. Confirmation of the genetic control of β -casein variation. J. Dairy Sci. 47:378-381. (AH g1-5)

Selection and Systems of Breeding

Beal, V. C. Jr. 1963. Effects of crossbreeding on part and whole lactations of dual purpose and dairy cattle. Ph.D. Thesis, Library, Purdue University, Lafayette, Indiana. (AH g2-23 Rev.)

Bereskin, B. and Touchberry, R. W. 1964. Effects of breed group, lactation production and pregnancy on body growth. J. Dairy Sci. 47:702. Abstract. (AH g2-23 Rev.)

Bond, J., Hooven, N. W. Jr., Thornton, J., Hiner, F. L. and Warwick, E. J. 1963. Influence of breed and plane of nutrition on beef production from dairy, dual purpose and beef cattle. Rome, Italy. Aug. 31, 1963. (AH d3-6)

- Evans, D. L., Branton, C. and Farthing, B. R. 1964. Heritability estimates and interrelationships among production per day of productive life, longevity, breeding efficiency and type in a herd of Holstein cows. J. Dairy Sci. 47:699. Abstract. (AH g4-2)
- Hatheway, C., Ludwick, T. M. and Weseli, D. F. 1963. The use of techniques of absorption and elution of bovine isoantibodies in the study of specificity of antigen and antibody and in the development of typing reagents. J. of Immunology 91:1. (AH g1-6)
- Hatheway, C. L., Ludwick, T. M. and Weseli, D. F. 1964. Isolation of F and V blood group factors of cattle and the relationship of siatic acid to F specificity. J. Dairy Sci. 47:6. p. 693. Abstract. (AH g1-6)
- Hooven, N. W. Jr., Bond, J., Warwick, E. J., and Hiner, R. L. 1964. Influence of breed and plane of nutrition on the performance of dairy, dual purpose and beef steers from birth to 180 days of age. J. Dairy Sci. 47:6, p. 690. Abstract. (AH d3-6)
- Labhsetwar, A. P., Tyler, W. J., and Casida, L. E. 1963. Analysis of variation in some factors affecting multiple ovulations in Holstein cattle. J. Dairy Sci. 46:840-842. (AH g2-5)
- Labhsetwar, A. P., Tyler, W. J., and Casida, L. E. 1963. Genetic and environmental factors affecting quiet ovulations in Holstein cattle. J. Dairy Sci. 46:843-845. (AH g2-5)
- Martin, T. G. and Starkenburg, R. T. 1963. Genetic correlations between beef and dairy traits in dual purpose cattle. Proc. Symposium on Beef Production by Dairy Cattle, World Congress on Animal Production, Rome, Italy. (AH g2-23 Rev.)
- Mi, M. P. 1963. Effects of mating systems on growth and production in Holstein cattle. Ph.D. Thesis. University of Wisconsin. (AH g2-5)
- Peterson, R. C. and Touchberry, R. W. 1964. Effect of breed, month of freshening and mean milk production on the within lactation variance. J. Dairy Sci. 47:701. Abstract. (AH g2-23 Rev.)
- Plowman, R. D., Hooven, N. W. Jr., and Harvey, W. R. 1963. A genetic study of feed efficiency in Holstein-Friesian cattle. Proc. of the XI International Congress of Genetics, The Hague, The Netherlands. Sept. 1963. Vol. 1, 14:45. (AH g1-4)
- Plowman, R. D. 1964. World meat supply, its distribution and outlook. J. Dairy Sci. 47:6. p.714. Abstract. (AH d3-6)

- Rausch, W. H., Ludwick, T. M. and Weseli, D. F. 1964. Inheritance of bovine transferrin types as determined by disc electrophoresis and their use in the determination of animal relationships. J. Dairy Sci. 47:6. p. 700. Abstract. (AH g1-6)
- Scott, L. M. and Martin, T. G. 1963. Effects of crossbreeding on feed efficiency of dual purpose cattle. Proc. Symposium on Beef Production by Dairy Cattle, World Congress on Animal Production, Rome, Italy. (AH g2-23 Rev.)
- Touchberry, R. W. 1963. Effects of crossbreeding and crisscrossing on the birth weight and gestation periods of dairy cattle. Proc. XI International Congress of Genetics. Vol. 1:p 266. (AH g2-23 Rev.)
- Wunder, W. W. and McGilliard, L. D. 1964. Heritabilities and genetic correlations for components of milk in Holsteins and Guernseys. J. Dairy Sci. 47:6 p. 700. Abstract. (AH g1-5)
- Young, C. W. and Cole, C. L. 1963. Crossbreeding experiments with dairy cattle. Minn. Farm & Home Sci. Vol. 21:1. (AH g2-1)

AREA NO. 6: DAIRY CATTLE - PHYSIOLOGY

Problem. Fundamental physiological research is required as a basis for improving lactational and reproductive performance of cattle. Breeding failure is a major reason for the disposal cattle. Further information is required on the physiological action of hormones in controlling reproductive activity, correcting reproductive abnormalities and stimulating lactation. Research on physiological processes related to growth and development, nutritional requirements and to heat tolerance of dairy cattle is also required.

USDA AND COOPERATIVE PROGRAM

This is a continuing program, almost entirely on basic research, conducted by physiologists and biochemists. The program is designed to elucidate the reproductive and lactational physiology of cattle utilizing physiological biochemical techniques and to determine physiological mechanisms related to heat tolerance. The work is in progress at Beltsville, Maryland, and co-operatively at the Wisconsin, New York, Massachusetts, Texas, Louisiana, Georgia Agricultural Experiment Stations. It is coordinated with the NE-41, W-49, and S-49 regional projects.

The Federal scientific effort devoted to the research in this area totals 7.7 professional man-years. Of this number, 2.9 are devoted to the physiology of reproduction, 2.0 to the physiology of milk secretion, 1.0 to the physiology of growth and development, 1.3 to environmental physiology, and 0.3 to program leadership.

A grant with the Veterinary School of the University of Sao Paulo, Brazil, provides for research on the anatomical and physiological characteristics affecting heat production and heat loss of Zebu, European and Zebu-European crossbred cattle and the nature and method of controlling the inheritance. Its duration is for five years, 1961-66, and involves PL-480 funds with a \$63,293 equivalent in Brazilian Cruzeiros. (Pertains to Area 5 also).

A grant has been initiated with the Veterinary Institute, Beit Dagan, Israel, in the Department of Reproduction, for work on a project entitled, "Comparative Studies of Repeat Breeders and Normal Cows and Heifers." It is for a five-year period and involves PL-480 funds to the extent of \$124,600 equivalent in Israeli pounds.

A grant was initiated with PL-480 funds with the Department of Applied Pharmacology, The Hebrew University, Rehovoth, Israel, on the mechanism of lactation and its augmentation by hypothalamic stimulation. It is supported for five years and is for \$126,767 equivalent in Israeli pounds.

PROGRAM OF STATE EXPERIMENT STATIONS

Current physiological research can be divided roughly into four categories, viz., digestion (especially rumen function), reproduction, milk secretion, and all other research. Several states are determining the major factors which influence the ratio of volatile fatty acids (VFA) produced in the rumen: some are determining the metabolic changes which occur before the VFA reach the blood stream; but only a few scientists are concerning themselves with the manner in which these VFA are utilized by the cow (intermediary metabolism). This is not because intermediary metabolism is not an important field of research but because of the scarcity of trained scientists. Digestion trials per se are receiving less attention than formerly.

A large amount of endocrine research is underway, especially as it relates to reproduction. Fewer workers are injecting the sex hormones promiscuously, or assaying the endocrine glands for their hormone content, and more are attempting to measure the hormone titer of the venous blood leading off from a ductless gland. Scientists at a few schools have become interested in the mechanisms which modify the normal secretion rate of endocrine glands, such as the role of the nervous system, the hypothalamus and the uterus. Such studies also include factors which modify the sensitivity of a target organ or tissue to the hormone(s) involved. Ova transfer, lyophilization of sperm and ova, what constitutes capacitance in spermatozoa, and how it relates to viability, plus many other studies, constitute the field of reproductive physiology.

Much endocrine research outside the field of reproduction also exists. The secretion rate of endocrine glands in vivo, especially the thyroid, the role of the parathyroid in milk secretion, especially the ability of the parathyroid to prevent milk fever, and factors which influence appetite are typical of these extra-reproductive endocrine studies. But the most important research in the field of endocrinology outside of reproduction is concerned with milk secretion. Innumerable other physiological reactions of the cow are being closely observed: temperature control, metabolism (detoxification) of insecticides and other poisons, resistance to disease, etc.

The total research effort on physiology of dairy cattle in 42 states is approximately 52.4 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. The corpus luteum. Human chorionic gonadotropin (HCG) was used to induce ovulation in ewes. Ewes that had their natural corpora lutea (CL) removed at the time of treatment with the ovulating dose of HCG had cycle lengths of 20 days. The new glands thus were formed in the relative absence

of progesterone. Ewes treated with HCG that had their natural CL left in the ovary for 2 days and then were removed had estrual cycles of 14 days, as did a group treated with HCG, natural CL removed but treated with progesterone. The data suggested that the presence of progesterone at the time new corpora are induced during the estrual cycle acts to shorten the life-span of such CL in ewes.

Cows were studied before and after the time of parturition to determine more exactly certain pituitary-ovarian relationships. The prepartum CL had a progesterone content of 26 $\mu\text{g/g}$ and were larger than CL on the day of calving which had no detectable progesterone. The pituitaries of the day-of-calving group had a significantly higher FSH level and lower LH level than the prepartum group. Injection of progesterone did not produce significant alterations in the FSH and LH levels of the pituitary glands.

In vivo treatment with oxytocin, glucose or both had no significant effect upon CL weight, initial progesterone concentration or synthesis of progesterone during incubation of luteal slices. When pregnenolone was added to the luteal slices, glucose, either in vivo or in vitro, increased the conversion of pregnenolone to progesterone ($P < 0.05$). The combination of both in vivo and in vitro glucose treatment caused a further increase in production of progesterone from pregnenolone. (AH h5-6)

Slices of bovine CL obtained during the estrous cycle were incubated for 2 hours in the presence and absence of luteinizing hormone (LH). LH stimulated progesterone synthesis and glycolysis in all CL with the exception of those obtained near the end of the estrous cycle. Progesterone synthesis in CL obtained day 19 or later can be restored by adding pregnenolone to the medium, suggesting that failure of pregnenolone formation may be responsible for the cessation of progesterone synthesis associated with luteolysis. (AH h5-4)

The mechanism by which hysterectomy prolongs the functional life of the corpus luteum was studied in heifers and rats. Both the CL and uteri were removed from heifers at the 9th-11th day of the estrous cycle. Such animals were capable of forming new CL, indicating that removal of the uterus does not block follicular development and ovulation.

Since cavernous sinus blood drains the pituitary, blood collected from the cavernous sinus may contain levels of pituitary hormones which can be related to pituitary and gonadal function. A technique was developed which consists of passing a needle through the foramen ovale into the cavernous sinus while the cow is restrained in an operating stall with its head tied to one side. Up to one liter of blood may be collected from each cow, heifer or calf. (AH h5-3)

2. The oviduct in sperm and ovum transport. Estrogen administered to rats on days 1-3 post-coitum or on day 3 post-coitum was found to interrupt pregnancy. The data suggest that pregnancy was inhibited by hastening the transport of ova into the uterus. In related studies on oviduct fluid secretion in sheep, the mean secretory rate of oviduct fluid at estrus was 2.3 times greater than 10 days after estrus, when it was at its lowest point. (AH h5-4)

3. Contraceptive action of intrauterine plastic devices in cattle and rats. Polyethylene spirals or loops were placed in the lumen of both uterine horns of parous Holstein cows. Small loops were expelled from the uterus but when larger loops were used they were completely effective in preventing pregnancy. Corpus luteum development was inhibited in about 1/3 of the estrous cycles. Cystic ovarian follicles developed in some of the cows. Slaughter studies suggested that the plastic devices in cattle uteri exert their contraceptive effect in large part by interfering with reproductive processes before ova reach the uterus.

In related experiments with rats, a thread was placed in one uterine horn to mechanically induce infertility and the rats were mated. No pregnancies occurred in the horns containing the contraceptive thread although the ovary on this side had ovulated to as great an extent as the contralateral ovary, as assessed by corpora lutea counts. Normal embryos were present in the non-thread horn in about the same frequency as normal rats. (AH h5-8)

B. Physiology of Milk Secretion

1. Histamine excretion of cattle fed various rations. Previous studies on the histamine content of cattle blood, milk, and urine demonstrated a much higher urinary histamine in heifers fed silage than in animals fed hay. Since silage feeding is often associated with an appetite problem, investigations were initiated to further characterize the role of naturally occurring histamine in various cattle rations upon the histamine concentration of rumen contents, feces, and urine. Examination of the feedstuffs, alfalfa hay, orchardgrass silage, and corn silage, revealed that by far the highest concentration of histamine was found in corn silage. The concentrations of histamine found in the urine and feces of cows receiving corn silage were several times greater than those found in the excreta of cows fed grass silage, and the grass silage levels were about twice that of the animals fed hay. In another study fistulated heifers were used and the histamine concentration determined in rumen contents, feces and urine when the animals were on various rations. A high urinary level, 127 µg/ml was found during corn silage feeding which decreased to 2 µg/ml on alfalfa hay. The dry matter feed intake was as much when fed corn or grass silage ad libitum as when fed hay, thus suggesting that the high amounts of histamine in the ration were not associated with a factor reducing intake. (AH h5-1)

2. Glycogen in normal and mastitic milk. Earlier studies demonstrated that mammary glands with induced mastitis had a higher tissue glycogen concentration than non-infected glands. Studies on milk from 11 mastitic cows demonstrate that the milk from mastitic quarters of the udder have a higher concentration of anthrone-positive material (glycogen) than milk from the non-infected quarters of the same udder. The glycogen concentration of mastitic milk was 7 times that of the normal milk ($P = 0.01$). A method for the disaccharide, lactose, which would effectively separate it from any monosaccharides present and from larger polymers, such as glycogen, was developed. (AH g3-8)

3. The mechanism of lactation and its augmentation by hypothalamic stimulation. The interrelationship of the hypothalamus and the interior pituitary gland in stimulating lactation was studied by depressing the activity of the hypothalamus with tranquilizers and other drugs. The research conducted this year demonstrated that milk producing neurotropic drugs are not necessarily hypothalamic depressors since antidepressants did not abolish the milk secretion. Culture of pituitary and hypothalamus together revealed that prolactin release was increased by perphenazine, estradiol and hydrocortisone. Estradiol and hydrocortisone act directly on the hypophysis whereas the action of perphenazine is mediated by the hypothalamus. Prolactin release was not affected by testosterone or oxytocin but was suppressed by estriol. Perphenazine, which was superior to chlorpromazine in eliciting hypothalamic lactation, was excreted in the milk. Tritium labeled compounds showed radioactivity in the milk equivalent to concentrations in the plasma. (A10-AH-3 Israel)

4. Effect of autoimmunization with semen on sperm production. At Beltsville, seven young Holstein bulls were put on a semen collection schedule of three times per week. After control periods of 2 months or longer, semen injections were started. Six bulls were injected intradermally each week with their own semen mixed with complete Freund's Adjuvant. The seventh bull was injected with the adjuvant and saline. After four months of treatment, the bulls showed no evidence of an effect on sperm or semen production. Small but significant amounts of anti-seminal plasma antibody were found in the blood of each of the bulls injected with semen. The control bull did not produce anti-seminal plasma antibodies. In three of the bulls which were slaughtered no evidence of tissue-fixed antibody was found. Rabbits injected with semen from each of the bulls all produced high titers of anti-seminal plasma antibodies. (AH g1-7)

C. Environmental Physiology

1. Effect of high fat rations and heat stress on milk production, milk composition and rumen acids. Three rations consisting of (a) alfalfa hay and concentrate; (b) hay and concentrates containing 10% soybean oil; and (c) hay and concentrates containing 10% hydrogenated vegetable fat were fed to lactating cows during alternate two week periods of cool ($60-75^{\circ}\text{F.}$) and hot (90°F.) environmental temperatures. Under the cool conditions ration (b) caused some decline in milk fat percent and a decrease in the rumen acetate-propionate ratio. The consumption of ration (c) was lower, but it increased milk fat percent slightly. The hot

environment decreased feed intake (20%), milk production (30%), milk fat percent (29%) and caused a significant decline in percent solids-not-fat and protein. There was some tendency for recovery in milk composition during the second week of heat stress. No significant differences were observed among rations under hot conditions in respect to milk yield or composition, although the soybean oil ration tended to produce more FCM. Total rumen acids were not significantly altered although there was an increase in the acetate-propionate ratio under the hot environment.

High fat feeding either as hydrogenated vegetable fat or soybean oil had little effect as compared to temperature on various physiological changes, although the cows receiving the hard fat ration had slightly higher body temperatures and respiration rates at the 90° temperature and rations x temperature interactions were significant for urine volume and specific gravity and hair coat depth.

At 90°F. there were significant decreases in body weight, urine specific gravity and pH; hematocrit % and respiratory tidal volume. There were significant increases in water consumption; urine volume; body temperature; respiration rate; respiratory volume, respiratory evaporation and insensible weight loss. The greatest changes occurred during the first week in all cases with some indication for recovery in most traits by the end of the second week. Hair coat depth and the number of red and white cells were not significantly influenced by the environmental changes. Among cow variance was important in the changes in most traits under the hot conditions indicating that the individual cows responded somewhat differently to the rations and changes in environment.

Under the conditions of this study, there was no clear evidence that the feeding of high levels of fat made the lactating cows more comfortable under heat stress. (AH g4-1)

2. Heifers can adapt to prolonged heat stress. Animals subjected to prolonged heat stress commencing in the winter months eventually adjusted their body temperatures to normal levels, whereas, this did not occur in the "summer conditioned" animals exposed to the same level of environmental temperatures. To study the physiological adjustments "winter-conditioned" animals made to heat stress, six three-year old Hereford heifers were subjected to a constant temperature of 90°F. and 60% relative humidity for 95 days commencing in January. The heat stress caused a significant change in all the physiological responses measured, but by the 95th day all had either plateaued at a level different from the preliminary period or returned to near normal levels. In most cases a readjustment was evident by the 40th day.

The average daily gain during the preliminary period was 1.79 lb. but declined to 0.62 lb. by the end of the 3rd week and to 0.23 lb. by the end of the 6th week. During the last 6 weeks, gains increased to 0.67 lb. and reached 0.75 lb. during the three-week post experimental period. The lower rate of gain

during the post period was partially due to the lowered level of feeding as the animals were about 70 lb. heavier. The reason for the marked decline in the rate of gain during the stress period is not clear as feed consumption never declined more than 10%, and for 10 of the 13 weeks the animals consumed all they were offered. There were neither significant changes in the digestibility of the dry matter nor in the total bacteria counts in the rumen during the heat stress period. Apparently, energy was used, at least partially, in combating the effects of the heat stress (ex., the energy expended in high respiration rates). (AH g4-1)

3. The relationship of physiological responses to blood and rumen constituents under heat stress. Multiple regression methods were used to determine the relationship of rectal temperature; respiration rate; water intake; hematocrit percent; and hair coat depth to blood and rumen constituents when animals were subjected to a 90°F. environmental temperature. The percent of variation (R^2) accounted for by these variables ranged from zero to 38% but there was little evidence of consistent significant variation being accounted for by the individual variables.

From this analysis it does not appear that rectal temperature, respiration rate, hematocrit percent, hair coat depth, and water consumption can be used effectively in estimating the changes that will occur in blood constituents and rumen acids under heat stress. (AH g4-1)

4. Adaptive responses of Holstein heifers to controlled and natural climatic conditions. At Louisiana State University, adaptive responses were studied in two groups (five animals each) of 12- to 15-month-old virgin Holstein heifers under controlled and cycled hot and cool and under natural climatic conditions.

Mean sweating rates from the forechest of the heifers by the capsule technique at air temperatures of 66, 77, 85, and 96°F. were 86.0, 107.2, 138.8, and 210.0 g/m²/hr., respectively. At 101°F. and 29 mm Hg animals previously acclimatized to summer conditions had an average sweating rate of 280.8 g/m²/hr. as compared with 132.0 g/m²/hr. for those previously exposed to cool conditions. The average number of sweat glands per cm² of skin by the biopsy technique was 991 ± 89. There was a significant correlation of 0.645 between sweating rate and the daily gain in weight.

The averages for daily body weight gain during the spring and cycled hot periods were 2.29 and 0.92 lb., respectively. Under the air conditioning and natural summer climatic conditions, the averages were 2.19 and 1.80 lb., respectively. (AH g4-1)

5. Studies of heat tolerance of Indian cattle and buffaloes. The study of responses of Haryana, Kankrej and Tharparkar breeds of cattle and Murrah buffalo to heat stress and humidity are being conducted at the Indian Veterinary Research Institute, Izatnagar, India, under a PL-480 grant. These studies are conducted in a psychrometric chamber under environmental conditions

consisting of cool (70°F.); hot-arid (120°F.), with 15% humidity; and hot-humid (105°F.), with 70% humidity.

Preliminary data indicate that exposure to both the hot-arid and hot-humid environments resulted in significant increases in respiration rate, respiratory volume, rectal temperature and pulse rate as compared to the cool conditions. Breed differences were not significant. The buffalo responded very similarly to cattle with few exceptions. The buffalo had slightly lower pulse rates under all conditions studied. The rectal temperature of the buffalo was at its highest under the hot-arid conditions, whereas the cow rectal temperature readings were highest under the hot-humid conditions.

Evidence thus far indicates that other variables will need consideration for fully differentiating the physiological characteristics of Indian cattle and buffaloes. (A7-AH-1)

6. Adaptability studies in Brazil. Commercial dairy herds in the Sao Paulo milk shed containing purebred or high grade Brown Swiss, Jerseys, and Holsteins were studied. The mean ages at first calving were 29, 35, and 41 months for Jerseys, Holsteins and Brown Swiss, respectively. The average time from calving to conception was 3.8, 4.3 and 4.7 months for Jerseys, Holsteins and Brown Swiss. The mean calving interval for the three breeds ranged from 14 to 17 months and gestation periods ranged from 274 to 286 days with the Brown Swiss having the longest interval in each case. There was no evidence of breed differences for length of time in the herds. Jerseys had the highest reproductive efficiency, but Holsteins excelled in milk yield per day of life. (S3-AH-7)

Twenty heifers (10 Zebu and 10 Zebu x European crosses) were kept in the psychrometric chamber for three month periods under each of the following assimilated seasonal conditions: spring (68°F.); summer (80°F.); fall (66°F.); and winter (54°F.). At the end of each of the three month periods the temperature was raised to 104°F. to determine the effect of heat stress on heifers accustomed to various seasonal conditions. There were significant seasonal effects reflected in the number of red and white blood cells, hemoglobin, hematocrit, body temperature and respiration rate. Seasonal effects were also important in the level of response at 104°F., particularly in the blood constituents.

This study indicates that the level of response to heat stress is largely dependent on the conditions the animals are exposed to prior to heat stress and also shows that among animal response to heat stress may be more important than among breed response. (S3-AH-7)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

- Armstrong, D. T., Black, D. L. and Cone, C. E. 1964. Metabolic studies with active and involuting bovine corpora lutea. Fed. Proc. 23, p. 462. (AH h5-4)
- Black, D. L., Duby, R. T. and Riesen, J. 1963. Apparatus for the continuous collection of sheep oviduct fluid. J. Reprod. Fertil. 6, pp. 257-260. (AH h5-4)
- Danon, A., Dikstein, S., and Sulman, F. G. 1963. Stimulation of prolactin secretion by perphenazine in pituitary-hypothalamus organ culture. Proc. Soc. Exp. Biol. Med., 114 pp. 366-368. (A10-AH-3-Israel)
- Donaldson, L. E. and Hansel, W. 1964. Collection of blood from the cavernous sinus in the cow. J. Dairy Sci. 47, pp. 98-99. (AH h5-3)
- Howe, S. R. and Black, D. L. 1963. Spermatozoan transport and leucocytic responses in the reproductive tract of calves. J. Reprod. Fertil. 6, pp. 305-311. (AH h5-4)
- Johnston, J. O., Kiddy, C. A., and Thatcher, W. W. 1964. Effect of autoimmunization with semen on spermatogenesis in dairy bulls. J. Dairy Sci. 47, p. 706. Abstract. (AH g1-7)
- Labhsetwar, A. P., Tyler, W. J. and Casida, L. E. 1963. Analysis of variation in some factors affecting multiple ovulations in Holstein cattle. J. Dairy Sci. 46, p. 840. (AH h5-6)
- Labhsetwar, A. P., Tyler, W. J. and Casida, L. E. 1963. Genetic and environmental factors affecting quiet ovulations in Holstein cattle. J. Dairy Sci. 46, p. 843. (AH h5-6)
- Labhsetwar, A. P., Tyler, W. J., Meyer, R. K., and Casida, L. E. 1964. Effect of gonadal hormones on the gonadotropic activity of the anterior pituitary gland of the spayed heifer. J. Animal Sci. 23, p. 569. (AH h5-6)
- Malven, P. V., Hansel, W., Wagner, W. C. and Roberts, J. 1963. Estrogenic activity in bovine luteal cyst fluid. J. Dairy Sci. 46, pp. 995-996. (AH h5-3)
- Schmidt, G. H., Chatterton, R. T., Jr., and Hansel, W. 1964. Mammary gland growth and the initiation of lactation in dairy goats. J. Dairy Sci. 47, pp. 74-78. (AH h5-3)

Stormshak, F., Inskeep, E. K., Lynn, J. E., Pope, A. L. and Casida, L. E. 1963. Progesterone levels in corpora lutea and ovarian effluent blood of the ewe. J. Animal Sci., 22, p. 1021. (AH h5-6)

Wrenn, T. R., Bitman, J., Cecil, H. C. and Gilliam, D. R. 1963. Histamine concentration in blood, milk and urine of dairy cattle. J. Dairy Sci. 46, p. 1243. (AH h5-1)

Environmental Physiology

Banerjee, M. R., Branton, C., Johnston, J. E., Guidry, A. J., and Briedenstein, C. P. 1964. Sweating patterns in Holstein heifers. J. Dairy Sci. 47, p. 346, Abstract. (AH g4-1)

Branton, C., Gangwar, P. C., Banerjee, M. R., Briedenstein, C. and Guidry, A. J. 1964. Adaptive responses of Holstein heifers to controlled and natural conditions. J. Dairy Sci. 47, p. 691, Abstract. (AH g4-1)

Guidry, A. J. 1963. Comparison of various methods for determining thyroid functions. M. S. Thesis, Louisiana State University Library. (AH g4-1)

Guidry, A. J., and Johnston, J. E. 1963. Various methods for determining thyroid functions. J. Dairy Sci. 46, p. 642. (AH g4-1)

Johnston, J. E., Guha, S., Joshi, B. C. and Ahmad, M. S. 1964. Adaptability of Haryana cattle to hot-arid or hot-humid environment. Proc. UNESCO Lucknow Symposium on Environmental Physiology, Lucknow, India.

McDowell, R. E., Ford, G. L., Moody, E. G. and Van Soest, P. J. 1964. Physiological responses of lactating cows fed dietary fats at high temperatures. J. Dairy Sci. 47, p. 692, Abstract. (AH g4-1)

McDowell, R. E. and Weldy, J. R. 1963. Water exchange of cattle under heat stress. Proc. of the 3rd International Biometeorological Congress, Pau, France. (AH g4-1)

Moody, E. G., Van Soest, P. J., McDowell, R. E. and Ford, G. L. 1964. Effect of dietary fats and heat stress on milk production and rumen acids. J. Dairy Sci. 47, p. 692, Abstract. (AH g4-1)

Weldy, J. R., McDowell, R. E., Bond, J. and Van Soest, P. J. 1964. Responses of winter conditioned heifers under prolonged heat stress. J. Dairy Sci. 47, p. 691, Abstract. (AH g4-1)

Weldy, J. R., McDowell, R. E., Van Soest, P. J. and Bond, J. 1963. Influence of heat stress on rumen VFA levels on some blood constituents in cattle. J. Animal Sci. 23, pp. 147-153. (AH g4-1)

Weldy, J. R. and McDowell, R. E. 1963. Feed intake and thermo-regulation in performance of cattle under high temperature. Proc. of the 3rd International Biometeorological Congress, Pau, France. (AH g⁴-3)

AREA NO. 7: DAIRY CATTLE - NUTRITION AND MANAGEMENT

Problem. Information on the nutritional processes and requirements of dairy cattle is needed to obtain a more precise evaluation of feeds and rations as a basis for improving feeding practices on farms. Shifts in sources of nutrients fed to dairy cattle require studies on the optimum combination and specific supplements needed in order to provide for the most profitable production. Also, dairymen need to reduce costs including man-hours of labor and develop better management in the use of improved types of dairy equipment and feeding, bedding, and milk handling systems.

USDA AND COOPERATIVE PROGRAM

The current program is conducted by biochemists, nutritionists and dairy husbandmen. At Beltsville, studies are in progress on the relationship between net energy, metabolizable energy, and total digestible nutrient values in dry roughages, silages, green roughages, and concentrates; and the relationship between digestibility and the chemical composition and solubility of various feed constituents. Calorimetric techniques are being applied to studies on the effects of dietary and physiological factors on energy metabolism and requirements of cattle. A cooperative project at Tifton, Georgia, has been initiated on the residues in milk resulting from the ingestion of pesticides and herbicides associated with the treatment of animals and crops.

At Beltsville, Maryland, research is being conducted on the effects of crop maturity, moisture content, preservatives, including methods of handling and conditions of storage, on the chemical quality, palatability and feeding value of silages. In conjunction with this effort, biochemical studies are being made to determine the effect of the composition of forage at the time of ensiling and of varying imposed conditions on the composition of the resulting silage. Related to the Beltsville studies is cooperative work at Lewisburg, Tennessee. The objective of the work at the Tennessee station is to determine the effectiveness of various practical ensiling procedures by varying such factors as moisture, preservatives, type of silo, etc. Pasture studies at Beltsville, Maryland, involve the effect of varying stocking rates on nutrient yields per acre and on production per animal.

A cooperative project at Logan, Utah, has been undertaken to measure the variations in efficiency of forage utilization by dairy heifers and to determine the factors which account for these variations.

The work at Beltsville, Maryland, also consists of studies on wilted silage as a forage for growing dairy heifers, the vitamin and mineral requirements of calves and deficiency symptoms using a synthetic type of diet with particular emphasis on vitamin A and magnesium deficiency.

Scientists at Beltsville are engaged in studies on the environmental conditions and the mechanisms of infection involved in bovine mastitis. In cooperation with Agricultural Engineering, Entomology, and Eastern Utilization, research is in progress on electrically-controlled and operated equipment for reduction of labor in dairy cattle management; on the evaluation and development of physical methods for control of flies and other dairy cattle pests; and on the relationship between management practices and milk quality including flavors.

Cooperative work with Agricultural Engineering and with the Georgia Coastal Plain Experiment Station is being conducted on the influence of management practices and other environmental factors on the adaptability of cattle to the Southeastern United States.

The Federal scientific effort devoted to research in this area totals 25.4 professional man-years. Of these 7.0 are in digestion and metabolism, 8.1 in forages, 3.1 in nutritional requirements, 3.6 in calf feeding, 2.7 in management practices, and 0.9 in program leadership.

A grant with the Government Agricultural College and Research Institute, Ludhiana, which is affiliated with Punjab University, Chandigarh, Punjab, India, provides for research on factors affecting the utilization of low-grade roughages and production of volatile fatty acids in the rumen of cattle. Its duration is for five years, 1962-67, and involves PL-480 funds with a grant of \$86,593 equivalent in rupees. (Pertains to Area 1 also).

A contract in the amount of \$10,000 per year to evaluate the feeding value of newer corn hybrids is in effect at the Maryland Agricultural Experiment Station. Duration four years.

A contract in the amount of \$25,000 per year to study the effects of level of concentrate feeding on cost of milk production is in effect at Cornell University. Duration four years.

PROGRAM OF STATE EXPERIMENT STATIONS

Calves. At what age and why do calves stop absorbing antibodies from the colostrum is still a moot question. Efforts are being made to reduce the milk feeding period. Different levels and kinds of vegetable oils along with emulsifiers, are being tried, especially for veal production. The newer antibiotics as well as digesters (enzyme preparations) are being studied. Others are interested in the synthesis of the B-vitamins in the intestine, in dextran as a source of iron, and still others in the zinc and manganese requirements of young calves.

Pregnancy and Lactation. Much more emphasis is now being placed on the condition of the cow at time of freshening including the permeability of the placental membrane to nutrients circulating in the maternal blood stream. Almost every station is still testing the effects of high quality forage

on milk production, or in vitro with an artificial rumen. The validity of the Morrison feeding standards are being questioned for high producing cows. As a result many experimental animals are being challenged with liberal grain feeding immediately on freshening. The effects on the composition of the milk of high grain feeding, including processing of the grain, are also under investigation. Efforts have also been made to increase the fat in the ration, especially unsaturated fats, in the hope of not only producing milk more economically but with more polyunsaturated fats present. High fat rations might also be less heating.

Copper compounds have been injected intravenously to see if they influence the susceptibility of cow's milk to become oxidized. Fluorine has been fed at various levels over long periods of time. There is also the problem of nitrogen fertilization on the availability of magnesium in forage, and of nitrates in the plant on the vitamin A reserves after feeding, including their effect on reproduction. What is the volatile compound in ladino clover that sometimes imparts an undesirable flavor to milk? Can these suspected compounds be tagged with a radioactive compound and thereby be traced and identified more readily? Will drugs like tapazole, thyroxine, diiodosalicylic acid, nitrofurazone and many others benefit the lactating cow?

Research on the use of milking machines, automatic feeding devices and free stall housing will be discussed in another section.

The total research effort on dairy nutrition and management at 43 states is approximately 76.4 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Energy Metabolism Laboratory. The major emphasis in the research program for the past year has been to conduct complete carbon, nitrogen and energy balance studies with dairy cows when they were pregnant, non-pregnant, lactating, dry, fattening, fasting, and at maintenance.

(a) Improvement of energy balance methods and procedures.

Additional progress was made during the year to reduce the time and labor required to calculate and summarize the results of respiration trials and energy balance experiments. A computer program for calculating the gas composition from the meter readings of the infrared and paramagnetic analyzers was prepared, and has resulted in the saving of manpower plus increased accuracy.

The method of listing the results of the computations of carbon, nitrogen and energy balance trials and digestion trials was modified so that they are suitable for publication without any transfer or typing of tabular material. An example of this method of preparation of data for publication was prepared and the proposal that this procedure be used in reporting

energy metabolism studies from other laboratories to facilitate completeness of publication, reduce costs of publication, and alleviate language difficulties is being considered by a committee appointed at the 3rd Symposium on Energy Metabolism, held May 19-22, 1964, in Troon, Scotland.

Specifications and plans for a digital data logging system to record data collected during respiration trials were prepared. The system will replace the present automatic data collecting system which is being rented. It will collect, record on typewriter, and punch into cards the data on gas flow, temperature, relative humidity, barometric pressure, animal activity, body temperature, respiration gas composition, and all necessary identification information from 6 respiration chambers. An alarm system to be used in conjunction with the digital data logging system has been installed, which has alleviated the necessity of having personnel in the laboratory at night and on weekends.

(b) Effect of ration composition on efficiency of utilization of metabolizable energy for milk production. Respiration trials and complete energy balance measurements with 7 lactating and non-lactating Holstein cows were conducted. The major purpose of the series of experiments was to determine the influence of ration composition on the efficiency of utilization of metabolizable energy for lactation. The rations were 100% alfalfa (ration C), 75% alfalfa (B), and 50% alfalfa (A), with the remainder of the estimated net energy being supplied as a concentrate mixture of corn and soybean oil meal. Results of the trials showed an increase in the efficiency of utilization of metabolizable energy for lactation and each additional substitution of concentrates for alfalfa on an equal estimated net energy (ENE) basis.

The efficiency of utilization of ME available for milk production, calculated by regression analysis of the data on a between animals basis, was $45 \pm 5.6\%$ for all alfalfa hay, $52 \pm 5.1\%$ for 75% alfalfa, and $56 \pm 4.2\%$ for 50% alfalfa. Using metabolizable energy consumed (ME_0) as the dependent variable, the efficiencies were 51, 56 and 58% for rations C, B, and A, respectively.

The above values were all considerably below what would have been expected based on previously reported experiments with lactating cows. However, the efficiency values can be markedly influenced by the assumptions made concerning the maintenance requirements and factors used to correct to zero energy balance. The data were computed assuming the maintenance requirement to be $131 \text{ kcal ME/W}^{0.75}$ and the correction factors for tissue deposition loss or gain to be $1.61+$ or $1.43-$. Using this approach, greater apparent efficiency values (54-65%) resulted, but the same conclusions regarding the influence of ration composition on the utilization of energy for milk production were reached. The mean efficiencies for converting available ME to milk were 65%, 61%, and 54% ($P < 0.05$) for rations A, B, and C, respectively.

The data were also computed by using covariance analysis to adjust to a common milk energy output. These computations showed that more ME was required for milk plus maintenance from the all-alfalfa hay ration than was required from a ration of alfalfa and concentrates when the ME was regressed on milk energy. This method of computation does not require the use of an assumed maintenance requirement, but it does not distinguish between efficiency for lactation and efficiency for maintenance.

(c) Utilization of metabolizable energy. The maintenance requirements of the lactating cows, calculated by regression, were 110, 110 and 109 kcal ME/W_{kg}^{0.75}/24 hr., respectively, for the three rations. All the above values were obtained using constants derived from data obtained within the experiment when the same animals were dry and non-pregnant, to correct for tissue gain or loss. The overall efficiency of utilization of the metabolizable energy of these rations for lipogenesis was $50.2 \pm 3.6\%$. The efficiency of utilization of metabolizable energy consumed above maintenance by dry cows varied from 45 to 56%, depending on the proportion of concentrates in the ration, with the higher efficiencies being on the rations containing concentrates.

(d) Relationships between rumen volatile fatty acids and efficiency of utilization of metabolizable energy. Samples of rumen contents were collected following each of the balance trials and were analyzed. The acetic acid present in the rumen declined from 71.4 to 65.3% (P < .05) as alfalfa hay energy was replaced with concentrate energy. A non-significant increase in propionic acid from 16.0 to 18.4%, and an increase in butyric acid from 7.9 to 10.4 molar percent occurred. The correlations between volatile fatty acid proportions and lactation efficiency calculated using an assumed maintenance requirement of 131 kcal/W_{kg}^{0.75}/24 hr. were: $r = -0.73$ for acetic acid, $+0.43$ for propionic acid, and $+0.67$ for butyric acid (P < 0.05).

These results would indicate that the reason for the increased efficiency of utilization of feed energy when concentrates replaced forage in the ration was because there was a greater proportionate production of propionic and butyric acid than of acetic acid in the rumen. Thus the type of feed fed can affect the efficiency of feed utilization through the type of fermentation produced in the rumen.

(e) Theoretical fermentation balance computations using respiration trial data. A theoretical fermentation balance equation derived by Wolin (J. Dairy Sci. 43:1452. 1960) was used to calculate the moles of fermented carbohydrate from data collected during energy balance experiments with lactating dairy cows. The proportions of the volatile fatty acids in the rumen of cows being fed rations varying in hay to grain ratios were incorporated into the balance equation. The total methane produced was measured during the respiration trials and was used to quantitatively estimate the moles of hexose sugar fermented for the three rations.

Methane production ranged from 266 to 536 liters per 24 hr., decreasing from 442 liters when the cows consumed 100% alfalfa hay to 409 liters when 50% of the ration ENE was concentrates. The quantities of hexose theoretically fermented were 5.246 kg for the all-alfalfa hay ration (ration C), 5.418 kg for ration B (75% hay), and 5.292 kg for ration A (50% ENE as alfalfa). These corresponded to 81.0%, 84.3%, and 86.4% of the actually determined digestible carbohydrates which were theoretically fermented.

The apparent digestible carbohydrates of alfalfa hay contain pigments, organic acids and tannins which are not fermentable. When corrections were calculated for the unfermentable portion of the alfalfa in each of the rations, carbohydrates which were actually fermented were 100% for ration C, 99.8% for ration B, and 101.9% for ration A. These computations suggest that all of the readily fermentable carbohydrate of each ration was actually fermented. However, many assumptions were made in deriving these results and further data will be needed to substantiate their validity.

(f) Practical significance to date of the energy laboratory studies. Total digestible nutrients (TDN) has been the usual method of expressing the energy values of feeds in the past. When comparing concentrates with each other relatively, the TDN values are essentially satisfactory. However, when comparing the replacement value of concentrates and forages with each other there will be considerable error. This error assumes considerable importance in purchasing feeds and in comparing the relative energy production of forages and concentrates per acre on the farm. The results of these experiments will in the future influence nutritionists to express the energy values of feeds in some terms based on the net energy concept. (AH h2-8)

2. Development of chemical methods for determining the nutritive value of feeds and forage. The nutritive value of forages varies dependent upon stage of maturity, species, method of preservation and fertilizer practices. It is highly desirable that suitable chemical methods be developed that will predict the nutritive value of forages. The previous report discussed new methods for the determination of acid-detergent fiber and lignin.

(a) Cell-wall constituents. A new method has been developed which divides the dry matter of forages into two fractions: cell-wall constituents, which represent the total of the fibrous fractions--lignin, cellulose, hemicellulose and fiber bound protein--, and the cell contents which contain the easily soluble matter that is rapidly digestible. The cell contents can be shown to be virtually completely digestible in ruminants and comprises 20 to 65 percent of the dry matter of forages. This new method differs in both purpose and function from the previously developed acid-detergent fiber (lignocellulose).

(b) Studies on the manner in which lignin affects digestibility. Statistical analyses, involving the form of mathematical expression of lignin in relation to the digestibility of fibrous fractions, showed that

lignin controls the availability of cell-wall constituents only, and has no effect on cell contents. On the other hand, lignin does control the digestibility in direct relation to which the concentration occurs in lignocellulose (termed lignification). The relationship is curvilinear and suggests a first order relationship between lignin and digestibility.

(c) Index of availability. Theoretical considerations have shown that the nutrients in forage are present in two different states that contribute to the resultant digestibility, the amount of nutrients in a state of lignification, and the amount of free cell contents which are independent of the effects of lignin. These two states can be expressed in a ratio as a percent and subtracted from 100 to give an availability index A.

$$\text{Availability Index} = 100 - \frac{\text{Lignin}}{\text{acid-detergent fiber (100-cell wall constituents)}} \times 100$$

Regression equations have been calculated from a group of 40 feeds including grasses, legumes, concentrates, mixtures and straws with the new availability index (A) with correlations of +0.94 with digestible dry matter, +0.05 with TDN, +0.95 with estimated net energy, and +0.96 with digestible energy.

Thus the nutritive value of all classes of feeds can be predicted with some accuracy by means of chemical analysis which has hitherto been impossible. The nutritive value can be expressed as digestible energy or estimated net energy. These new methods will undoubtedly replace methods now being used in the forage testing laboratories in the various states.

(d) Studies on voluntary intake. A total of 121 forages on which voluntary intake has been measured have been analyzed chemically. The relationships of lignin and acid-detergent fiber with voluntary intake reveal intense species differences. The only consistent relationship that can be drawn across all forages is that of the total fibrous fraction, cell-wall constituents (CWC). As this fraction increases, voluntary intake declines with an increasingly negative slope. In forages with a low CWC, digestibility and intake are not apparently related. In forages with a high CWC, intake is highly correlated with both chemical composition and digestible dry matter. This suggests that the relationship between digestible dry matter and voluntary intake depends on the proportion of total digestible nutrient from cell-wall constituents. Accuracy of prediction from the regression of cell-wall constituents on voluntary intake is poor for high quality forage and possesses some precision in low quality forages.

(e) Weighing techniques and sample preparation. A procedure for the weighing of hot crucibles and samples directly from the drying oven has been perfected and eliminates the use of dessicators causing a considerable saving of time. A technique using acetone-drying to prepare wet samples in a dry state without the use of heat has been developed for the purpose of avoiding

formation of lignin artifacts. This adds considerable to the accuracy of the lignin method as well as the accuracy of interpretation which can be placed on the values obtained. (AH h2-6)

3. Chemicals in milk. Dimethoate toxicity. In 1961 at Tifton, Georgia, a corn crop was sprayed with dimethoate, made into silage and fed to lactating dairy cows. During the feeding trial some of the cows on the higher intake levels of 0.13 and 0.28 mg/Kg/day displayed toxicity symptoms including blood clots in the feces and chocolate colored urine. In order to gain further information in respect to the toxicity of the insecticide, alfalfa was sprayed at Beltsville with 2 lb/acre (about 4 times the recommended level) and harvested as silage with the application of 100 lb sugar per ton of fresh material. The resulting silage containing 54-73 ppm of residue was fed to three cows. One Jersey died after 41 days while consuming 2.04 mg/Kg/day, and a second Jersey had to be sacrificed after 44 days while consuming 3.45 mg/Kg/day. A third cow, Holstein, consumed 2.55 mg/Kg/day for 93 days and failed to display any toxic symptoms.

The amounts of dimethoate consumed at Tifton and at Beltsville is below the toxic level as previously determined elsewhere. However, it is known that the oxygen analog of dimethoate is about 10 times more toxic than the dimethoate itself. Whether the oxygen analog or other decomposition metabolites are present and peculiar to silage is not known. Further work is required and is being conducted at Tifton in respect to the use of dimethoate on crops to be made into silage. (AH h2-9)

B. Forage Evaluation and Utilization

1. Effect of moisture level on preservation and feeding value of alfalfa silage. Previous work has shown that alfalfa stored at about 55% moisture content in conventional tower silos was equal in feeding value to barn-dried hay. Further work was required to determine the optimum moisture level for storage and feeding value. Alfalfa forage was harvested and stored in conventional tower silos at three moisture levels 60%, 50%, and 40%. Storage losses were least for the 60% silage and greatest for the 40% silage. Spoilage was a general problem in the 40% silage. Feeding value of the 50% moisture silage was highest on the basis of intake, milk production, liveweight gains, and digestibility. Simple correlations indicated that at moisture contents higher than 50%, the chemical changes in the silage were less desirable (increased butyric acid and lowered sugar content) and intake was lower.

It was concluded that an average moisture content between 50 and 60% is optimum for storage in conventional silos and that the intake and feeding value of the silage will be equivalent to barn-dried hay. Thus the difficulty previously encountered of lowered intake of dry matter with high moisture silage (60% moisture and above) has been overcome by procedures which can be fully automated and without the need for special equipment. (AH h3-3)

2. Low-moisture grass silage stored in a bunker silo. Previous studies of low-moisture silage have been confined for the most part to alfalfa or alfalfa-grass mixtures. Because of the successful experience in storing low-moisture alfalfa in a bunker silo, it was decided to investigate the possibility of extending the method to grass crops. Twenty-two tons of second cutting orchardgrass with an average moisture content of 45% was stored in a bunker silo. The sides and top surface were sealed with 4 mil polyethylene plastic. A dry matter recovery of 87% appears promising in spite of some mechanical damage by tramping with cattle and puncturing of the plastic cover. Dry matter consumption of the silage was significantly higher than from direct-cut orchardgrass silage stored in a conventional tower silo. (AH h3-3)

3. Effect of nitrogen fertilization and stage of maturity on the quality and feeding value of orchardgrass silage. Nitrogen fertilized and unfertilized orchardgrass was ensiled at two stages of maturity using the direct-cut method. Nitrogen fertilization increased the crude protein content of both forage and silage, reduced silage consumption and liveweight gains at both early and late maturity stages. The 10-day delay in harvest time reduced dry matter digestibility about 7 units in the nonfertilized silage, but only 2 units in the nitrogen fertilized silage. Within cow variations in silage dry matter consumption were largely explainable (63%) by a multiple regression using four factors, namely, dry matter percent, butyric acid percent, lactic acid percent, and the ratio of ammonia nitrogen to total nitrogen. It will be noted that the use of nitrogen fertilizers on orchardgrass, while increasing yield of dry matter per acre, increases the difficulty of making a good quality of silage and is one of the reasons for present confusion on proper methods for harvesting and processing the crops as silage. (AH h3-3)

4. Methods of improving the quality of orchardgrass silage produced from nitrogen fertilized grass. Previous experiments have shown that direct-cut orchardgrass silage produced from heavy nitrogen fertilization was generally of poor quality and the intake by cattle reduced. Addition of sugar to provide an initial sugar to protein ratio of 0.5 was somewhat helpful as was the use of a flail cutter which causes some bruising of the forage. Wilting the crop to about 37 and 45% dry matter was more effective. Limited intake data indicated that wilting was more effective than the addition of sugar on increasing dry matter consumption. It has generally been thought that silage reaches a stable condition after 30 days of fermentation. Borings taken 62 days after ensiling showed a marked loss of lactic acid and a concomitant gain in acetic acid and ammoniacal nitrogen. (AH h3-3)

5. Biochemical studies relating to silage investigations. Accumulation of nitrate occurs in some forage crops which have been heavily fertilized with nitrogen and produced under certain conditions. Because the nitrate is toxic to animals and the nitrous oxide fumes from the silo can cause deaths if inhaled, chemical studies were conducted using ground orchardgrass forage in quart jar silos utilizing various treatments. In the first cutting

of orchardgrass, inoculation with silage juice or heating and inoculation, resulted in appreciably elevated pH and also produced sizable reductions in nitrate content. In the second and third cutting spontaneous removal of nitrate occurred without any treatment other than grinding. Neither sulfur, urea, inoculation, heating to 80°C and inoculation, sodium thiosulphate nor iodine appeared to accelerate the conversion.

Evolution of gases from the silages was reduced in first cutting by inoculation and/or heating. Since nitrate reduction also occurred with a rise in pH, complete reduction to NH_4 and retention in the silage is suggested. (AH h3-1)

6. Efficiency of a bunker silo for storage of corn silage. One hundred and twelve tons of corn were cut and stored in a bunker silo and sealed with a weighted 4 mil polyethylene plastic cover. After 3 months storage, the silo was opened and fed for 4 months during the Winter. 91.8% of the stored dry matter was recovered as feedable silage. This experiment indicates, along with previously collected data, that bunker silos can be managed in such a way that 90% of the stored corn crop can be recovered as good silage. In view of the generally low initial cost of the bunker and the ease of filling, they appear to have an important place in economical storage of corn silage. (AH h3-3)

7. Use of fungicides for reduction of surface spoilage in low-moisture alfalfa silage. Surface spoilage of low-moisture silage is a problem of some concern where this method is used to preserve forage crops. Two fungicides, Crag Mylon (3-5 dimethyltetra hydro -1, 3-5, 2H - thiadiazine -2-thione) and para formaldehyde were studied in 4 x 8 silos for their effectiveness in preventing surface spoilage. Both materials produced promising results, but inconclusive evidence for reducing top spoilage. (AH h3-3)

8. Comparison of RS-610 grain sorghum and star pearl millet as silage with the utilization of the regrowth for late summer soiling. Studies conducted at Lewisburg, Tennessee, showed that RS-610 grain sorghum produced more dry matter per acre than Starr Pearl millet (9871 vs 7602 lbs per acre). On the other hand, intake of dry matter and milk production per cow was significantly higher for the millet. However, the grain sorghum regrowth produced slightly more milk when fed as green chop. (AH h3-12)

9. Stored forage compared to rotational grazing for lactation. A study has been in progress at Lewisburg, Tennessee, comparing stored forage systems with rotational grazing for lactating dairy cows. During the fourth year of the experiment, the cows on pasture produced slightly more milk than those fed stored forage (45.0 vs 43.1 FCM per day). On the other hand, carrying capacity in days for each 8 acre field was 1645 vs 3010 days. The plant population in percent were alfalfa 8.1 vs 48.9, orchardgrass 51.6 vs 29.7, Ladino clover 21.0 vs 16.2, weeds 19.3 vs 5.2. Thus there would appear to be considerable advantage to the stored forage system in terms of milk per acre and persistence of the pasture stand. (AH h3-12)

C. Heifer Feeding

1. Ammoniacal nitrogen relationships as affecting silage intake.

Studies have continued in an attempt to determine why dry matter consumption by cattle of high moisture grass and/or legume silage (65% moisture and above) is less than for barn-dried hay, cut from the same field at the same time. The storage of grass and/or legume forages as high-moisture silages changes the distribution of the nitrogen fraction into various forms. A larger proportion of the total nitrogen appears as ammoniacal nitrogen compared to hay. One physiological mechanism, by which ammonia might limit consumption, is by absorption of excess ammonia from the rumen into the blood.

Experimental silages were produced by adding sugar at the time of ensiling to inhibit ammonia production. Urea, a good source of ammoniacal nitrogen when metabolized in the rumen, was added to other silages before feeding. These two additions, sugar before ensiling and urea after ensiling, supplied the animals with forages in which the naturally occurring simultaneous changes in chemical content were shifted from their normal relationship.

Analyses performed for rumen ammonia showed that it reached about one-half that usually shown to exceed the conversion threshold of the liver which would result in an increased level of blood ammonia.

Other experiments comparing the rumen ammonia level while feeding a hay ration compared to a silage ration have shown no difference in rumen ammonia level. The feeding of urea to 2 animals, receiving hay and 2 animals receiving hay and grain (50-50) in amounts of 100, 200 and 300 grams per day, did not cause a progressive increase in rumen ammonia levels. In fact, the animals seem to be able to adapt themselves to these intakes. Dry matter intake was only slightly reduced at the high intake of urea. These results indicate that the ammoniacal nitrogen level in silage does not act to reduce intake by increased absorption of ammonia from the rumen. However, there remains a second possibility that the ammoniacal nitrogen level in silage may limit feed intake by an effect on taste of the silage. (AH h1-1)

2. Histamine relationships.

It has been suggested that the histamine content of silage might affect intake and it has been reported that the histamine content of the urine of silage-fed animals is high. Silages and hay fed to dairy heifers, and the fecal and urinary samples collected from these animals, were analyzed for free histamine. In the silages analyzed, the correlation between the logarithm of the histamine concentrations and the dry matter intake were low, although the correlation between the logarithm of the histamine concentrations and the dry matter content of the silages was high.

Hay and urine of hay-fed heifers were relatively low in histamine. In haylage and silage-fed heifers, high urinary and fecal histamine levels

were not necessarily associated with high histamine intake. The addition of 5 gm histamine-dihydrochloride, to an animal consuming 2.1 lb of chopped alfalfa hay per 100 lb body weight, did not decrease dry matter intake. The data suggest that there is no relation between silage dry matter intake and histamine concentration of the silage. (AH hl-1)

D. Management Practices, Equipment and Facilities

1. Bovine mastitis. Body cell counts were made on 3,872 quarter milk samples from the Beltsville herd and 492 quarter samples from two other herds. These quarters were determined to be free from bacterial infection and normal in all respects. The number of body cells per ml of fore milk ranged from less than 30,000 to more than 8,000,000. Even though a majority of these non-infected quarter samples contained less than 500,000 cells per ml, about 25% of them had counts exceeding 1,000,000. Preliminary data indicate that time of day the quarter samples are drawn has a large influence on the cell count. Samples taken a few hours after milking have higher counts than those drawn a short time before milking.

Two commercial milking machines are being tested on contemporary groups of cows. One machine operates at 15" HG vacuum, has a pulsation rate of 60 per minute and a pulsation ratio of 2-1/2:1. Statistics for the other machine are 12-1/2" Hg vacuum, 48 pulsations per minute and a 1:1 pulsation ratio. The machine with the higher vacuum, faster rate and wide pulsation ratio milks faster during the maximum rate of flow and thus requires less machine time until the milk ejection drops to 1 lb per minute. However, more stripping time is required than for the other machine. The data indicate a machine-cow interaction, especially with cows that are slow milkers. The total milking time per cow ranges from 2.8 to 10 minutes. The average for all cows was 5.5 minutes with no difference between machines. To date, no significant differences between machines have occurred in incidence of mastitis, new udder infections, or number of body cells shed. The high vacuum machine has caused some teat-end erosion. (AH g3-8)

2. Relation of rate of cooling to milk quality. Investigations were begun to determine the effect on milk quality of varying the rate of cooling provided in mechanically refrigerated farm bulk milk tanks. From a series of experiments with an ice-bank tank, it appears that when the quality of incoming milk is high (standard plate count of 10,000 to 40,000) the cooling rate can be decreased considerably below the maximum capacity of the refrigeration system without resulting in an increase in the microflora. The operating conditions leading to minimum detectable bacterial multiplication lay between a five-minute and ten-minute cycle with one-half minute cooling water circulation. These two cycles cooled the first milking of the trial at rate of approximately 75 and 48 BRU/hr/gal from the end of milking to 50°F, respectively. From the beginning of milking, the milk was cooled to 50°F in about 4 and 6 hours. In the latter situation, the bacterial population rose to 8×10^6 per ml by the end of the 48-hour period. In the range studied, changes in cooling rate did not affect either the flavor score of the milk or the acid degree value.

The relation between the temperature history of the milk and the bacterial growth rate was not constant. An initial lag, followed in the second cooling and storage period by temperature-dependent multiplication, was expected. In the period following the third milking, however, there was an actual decrease in the bacterial population. The magnitude of this decrease varied directly with the population. During cooling and storage following the fourth milking, the bacterial population again increased at a temperature-dependent rate. This anomalous pattern of growth will be further investigated. (AH g3-10)

3. Physical methods for fly control. Tests of the effectiveness of various commercial lamps in attracting flies to electrocutor grids were conducted in outdoor cages. Face flies were the most effectively attracted of three species tested and responded to daylight, blacklight BL and blacklight BLB lamps; however, this has only proved successful with confined populations, and attempts to kill face flies around barns with similar traps have been ineffective. House flies also were attracted by daylight, blacklight BL and blacklight BLB lamps, the percentage of a confined population attracted usually being 40-65%. Stable flies were less attracted to light than either face flies or house flies. Observations indicated that the blood feeding schedule prior to testing greatly affects their behavior.

Suitable procedures were developed for testing the reactions of face flies to monochromatic light in a Y-chamber. Initial trials indicate greatest attraction in the blacklight ultra-violet region with progressively reduced attraction at both longer and shorter wavelengths.

Biological studies of both stable flies and face flies were conducted in an effort to determine characteristics which might be capitalized upon in devising control measures and to learn more about the flies' reproductive cycles. Successful matings of stable flies occurred between one-day-old males and five-day-old females and between one-day-old females and five-day-old males; however, a greater proportion of successful matings were indicated when both males and females were five days old. Oviposition studies indicate females begin laying eggs when about 8 days old and may lay as many as 600 eggs in their lifetime, which may be as long as 4-6 weeks.

Contrary to previous information, no significant differences could be found after four generations among colonies of face flies reared under 5, 50 or 500 ft.-candles of illumination, simplifying colony room requirements. Female face flies can lay fertile eggs within 4 days after emergence, deposit their eggs in batches of about 20 eggs per batch at intervals of 2-8 days, and are capable of depositing eggs throughout their lifetime. One female which did not have an opportunity to mate after she was four days old lived 58 days and laid 230 eggs in 10 batches from which 189 pupae were collected.

Approximately 24,000 individually marked face flies were released in an effort to study the flies' dispersal. Marked flies were found two miles from the

release point 24 hours after release and 4 miles away after five days. Attempts to locate face flies in barns at night during the summer have been completely negative. Marked face flies have been observed resting in trees at night. (AH g3-12)

4. Evaluation of fans, sprinklers and shade to alleviate summer temperature conditions for lactating cows. Two years of work has shown that providing fans and sprinklers for lactating Jersey cows during the summer months at Tifton, Georgia, had little effect on cow performance as compared to effect of shade alone. Average daily roughage dry matter intake per cwt. was 1.81 pounds for cows with shade plus fans and sprinklers as compared to 1.76 pounds for the shade treatment. Cows on the shade treatment had an average daily decline in milk yield of 0.185 lb as compared to 0.196 lb for cows on the shade plus fans and sprinklers. Body weight changes of cows on the two treatments were not different. The average A.M. and P.M. rectal temperature was 101.7 and 102.4°F for the shaded cows and 101.9 and 102.2°F for the shaded, fanned and sprinkled cows. Previous work had shown that provision of shades had little effect on summer production of dairy cat cattle in this environment.

The proper height of artificial shades for cattle in the southeast was studied during the summer for three years at Tifton, Georgia. Temperature and radiation at animal height was consistently less under the 6 foot shades than under either 9 or 12 foot shades. (AH g4-3)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Digestion and Metabolism

- Flatt, W. P. 1963. "Conducting animal research". National Science Foundation Summer Science Training Program. Life Agricultural Sciences. V.P.I. (AH h2-8)
- Flatt, W. P. "Telemetering metabolism from large animals". Bio-Telemetry - A Progress Report. 18th Annual Instrument-Automation Conference and Exhibit of the Biomedical Sciences Division of the Instrument Society of America. Chicago, Ill. Sept. 9, 1963. (AH h2-8)
- Coppock, C. E. 1964. The utilization of metabolizable energy for milk production by dairy cows. Ph.D. Thesis, University of Maryland. (AH h2-8)
- Flatt, W. P., Coppock, C. E., Moore, L. A., Stewart, W. E., Hemken, R. W. and Davis, R. W. Energy utilization by lactating dairy cattle. Proc. Md. Nutrition Conference p. 29-36. March 1964 (AH h2-8)
- Flatt, W. P., Coppock, C. E., Moore, L. A., and Hemken, R. W. 1964. Energy balance studies with dry, non-pregnant dairy cows consuming pelleted forages. Proc. 3rd Symposium on Energy Metabolism. Troon, Scotland. (AH h2-8)
- Flatt, W. P., Coppock, C. E., and Moore, L. A. 1964. Energy balance studies with lactating, non-pregnant dairy cows consuming rations with varying hay to grain ratios. Proc. 3rd Symposium on Energy Metabolism. Troon, Scotland. (AH h2-8)
- Flatt, W. P., Coppock, C. E., Moore, L. A., Heath, A., Dickinson, F. and Tabler, K. A. 1964. Automatic computation and summarization of carbon, nitrogen and energy balance experiments. Proc. 3rd Symposium on Energy Metabolism. Troon, Scotland. (Also USDA, ARS 44-142-1, May 1964) (AH h2-8)
- Flatt, W. P., and Heath, A. 1964. A proposed method of publication of energy metabolism research data, based on the use of an electronic computer and a standard format. Proc. 3rd Symposium on Energy Metabolism. Troon, Scotland. (Also USDA, ARS 44-142-1, pp. 6-16. May 1964) (AH h2-8)
- Coppock, C. E., Flatt, W. P., Moore, L. A., and Stewart, W. E. 1964. Effect of ration composition on the utilization of metabolizable energy for milk production by dairy cows. J. Dairy Sci. 47:703. (Abstract P77, also ARS Mimeo, June 1964) (AH h2-8)
- Coppock, C. E., Flatt, W. P., Moore, L. A. and Stewart, W. E. In press. Effect of hay to grain ratio on the utilization of metabolizable energy for milk production by dairy cows. J. Dairy Sci. (AH h2-8)

Coppock, C. E., Flatt, W. P., Moore, L. A. and Stewart, W. E. In Press. Relationships between end-products of rumen fermentation and the utilization of metabolizable energy for milk production. J. Dairy Sci. (AH h2-8)

Williams, W. F., Hoernicke, H., Waldo, D. R., Flatt, W. P., and Allison, M. P. 1963. Ruminal carbonate as a precursor of eructed methane and carbon dioxide. J. Dairy Sci. 46:992. (AH h2-8)

Hoernicke, H. H., Conrad, H., Flatt, W. P. and von Engelhardt, W. 1963. Untersuchungen ueber den Vorgang des Ruktus bei Wiederkaeuern. Proc. 17 World Veterinary Congress, Hannover, Germany 1:225. (AH h2-8)

Hoernicke, H. H., Williams, W. F., Waldo, D. R. and Flatt, W. P. 1964. Composition and absorption of rumen gases and their importance for the accuracy of respiration trials with tracheostomized ruminants. Proc. 3rd Symposium on Energy Metabolism. Troon, Scotland. (AH h2-8)

Van Soest, P. J. 1963. The use of detergents in the analysis of fibrous feeds. I. Preparation of fiber residues of low nitrogen content. J. Assoc. Off Agr. Chem. 46:825. (AH h2-6)

Van Soest, P. J. 1963. The use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Assoc. Off. Agr. Chem. 46:829. (AH h2-6)

Van Soest, P. J. 1964. New chemical procedures for evaluating forages. J. Animal Sci. 23:838. (AH h2-6)

Forage Evaluation and Utilization

Gordon, C. H., Derbyshire, J. C., Jacobson, W. C., Melin, C. G., and McCalmont, J. R. 1963. Use of conventional tower and bunker silos for low-moisture alfalfa silage. Agronomy J. 55:314. (AH h3-3)

Moore, L. A. 1964. Symposium on forage utilization: Nutritive value of forage as affected by physical form. Part I. General principles involved with ruminants and effect of feeding pelleted or wafered forage to dairy cattle. J. Animal Sci. 23:230. (AH h3-3)

Zimmer, Ernst and Gordon, C. H. 1964. Effects of wilting, grinding and aerating on losses and quality in alfalfa silage. J. Dairy Sci. 47:652. (AH h3-3)

Moore, L. A. 1964. The place of liberal concentrate feeding to dairy cattle. ARS 44-133. (AH h3-3)

Miller, R. W., Waldo, D. R., Okamoto, M., Hemken, R. W., Vandersall, J. H. and Clark, N. A. 1963. Feeding of potassium bicarbonate or magnesium carbonate to cows grazed on Sudan grass or Pearl Millet. J. Dairy Sci. 46:621. (Abst.) (AH h3-3)

Management Practices, Equipment and Facilities

Smith, J. W. and Schultze, W. D. 1964. Cell count variations in milk from bacteria free and clinically normal individual quarters. J. Dairy Sci. 47:696. (Abst.) (AH g3-8)

Conlin, B. J., Corley, E. L. and Tyler, W. J. 1964. Sources of variation in monthly and twelve-month rolling DHIA herd average milk and fat yield. J. Dairy Sci. 47:701. (Abst.) (AH g5-1)

AREA NO. 8: POULTRY - BREEDING

Problem. Poultry breeders have made tremendous progress in recent years through the application of new genetic principles revealed by basic research. Improvement in many of the economic traits has attenuated and new methods of releasing useful genetic variation are needed. Information is needed as to the relative rates of progress which will result from various breeding systems for improving such economic traits as egg and meat production. Furthermore, information is needed as to whether different breeding systems are required or are more efficient at different stages of the breeding program. In order to design the most efficient breeding systems, knowledge of the heritabilities, genetic correlations between traits and the effects of genotype-environment interactions are required. The physiological basis for the action of certain genes is unknown and information regarding these processes would lead to better control of heredity for optimum performance. The economics of production should be improved through knowledge gained on the genetic aspects of feed utilization and selection under various stress conditions.

USDA AND COOPERATIVE PROGRAM

This is a continuing long-term program involving basic and applied studies of the inheritance of egg production and broiler characteristics. Scientists with majors in genetics or biochemistry and minors in physiology or statistics are involved. Much of the research is conducted within the framework of four regional projects. In addition to major contributions to the establishment and maintenance of central facilities, the USDA also provides coordinating personnel located at Athens, Georgia; Lafayette, Indiana; and Beltsville, Maryland. The close working relationship between the USDA and State experiment stations in the four regional projects provides for integrated research on a large scale without duplication of effort. Research at Beltsville, Maryland, involves the selection of lines under stress of nutritional deficiency and for differences in feed utilization efficiency, including a study of genetic, biochemical and physiological differences between these lines. Selection for response in egg production to "18-hour" days is conducted in cooperation with AERD. Research in the North Central region is on egg production traits and is done at the Regional Poultry Breeding Laboratory, Lafayette, Indiana, and at 12 cooperating State experiment stations. In the Southern region the emphasis is divided between egg and broiler traits and the work is conducted at the Southern Regional Poultry Genetics Laboratory, Athens, Georgia, and at 14 cooperating State experiment stations. The work in the Northeastern region involves the improvement of chickens through genetic and physiological studies and is conducted under cooperative projects at 11 cooperating State experiment stations. Cooperative work on turkeys is carried on with six Western States.

A Research and Marketing Act contract with Purdue University Agricultural Experiment Station for the study of diallel crosses of four light and four heavy type inbred lines was concluded. The study extended over a period of three years and involved a statistical analysis of data obtained from inbred lines of poultry and their combination in crosses from the North Central Regional Poultry Breeding Project.

The Animal and Poultry Breeding Department, Ministry of Agriculture, Dekki, Giza, Egyptian Region, U.A.R., is conducting a study to improve and evaluate the Fayoumi and Dandarawi fowl. This P.L. 480 project was initiated in 1963 for a duration of five years. Other P.L. 480 projects initiated during the year include a pilot project designed to study the influence of environmental stress with *Tribolium*, to be conducted by the Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain, and a project to evaluate the bacteriological problems in artificial insemination of hens to be conducted by the Hebrew University, Faculty of Agriculture, Rehovot, Israel. The latter two projects are scheduled for a duration of five and two years respectively.

A total of 7.3 professional Federal man-years is devoted to this program annually. Of this number 3.6 man-years are devoted to genetics and inter-relations of performance traits, 3.1 to selection and systems of breeding and 0.6 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

Research is concerned with estimating genetic parameters, gene-environmental interactions and genetic and phenotypic correlations among morphological and physiological traits of economic significance in chickens and turkeys. These estimates are used for evaluation of breeding systems.

Much of the breeding research is conducted within the framework of four Regional poultry breeding projects, NC-47, S-57, NE-51 and W-78, in co-operation with the USDA. Work on NC-47 is designed to determine rates of progress obtainable in populations of chickens under various systems of breeding and to estimate genetic changes produced by these systems. S-57 is concerned with establishing the magnitude and importance of genotype-environment interactions in meat and egg production stocks. The pleiotropic effects of known genes in relation to reproductive performance of chickens is studied in NE-51. W-78, a turkey breeding project, is concerned with efforts to improve hatchability of turkey eggs at high altitudes through selection for hatchability at different altitudes.

Considerable effort is being devoted to studies of genetic traits that are associated with reproductive fitness, fertility and hatchability particularly in turkeys. Many genes in poultry have multiple effects and the relationship of plumage color genes, blood group genes and other easily

identified marker genes to growth rate, viability, egg production and other economic traits is being investigated. Studies are being made to identify genetically-controlled physiological functions for possible use as selection criteria to improve growth and reproductive efficiency; to determine the ability of chickens to make genetic adaptations to atypical light-dark cycles and to determine if selection for growth rate is more effective using deficient rations as compared with adequate rations.

The total State scientific effort devoted to poultry breeding research is 50.6 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits.

1. Genetic aspects of nutritional deficiencies. Selection for fast and slow growth on both a methionine deficient diet and on a normal diet for two generations indicates that lines differing in growth rate can be developed under each environment. Progress has been made from selection in divergent directions under each environment when compared with the randombred control population. Chicks reared on the deficient diet were restricted in growth at 3-weeks of age to approximately one-half that of chicks on the normal diet. When fed a normal diet from 3- through 8-weeks of age the chicks did not compensate for the reduced growth rate observed during the treatment period. (AH el-48)

2. Biochemical basis for genetic differences in growth rate. Lines of chickens established by selection for differential growth performance on adequate and methionine deficient diets are being used to investigate the nutritional basis of the genetically-induced growth rate alteration. Although the fast growing lines are much heavier than the slow growing lines at 3 weeks of age, the methionine and protein requirements of all 4 lines are similar. Using a conventional growth assay, the optimal dietary concentrations were found to be .39% and 18.4% for methionine and protein, respectively. Additional evidence that no differences in nutrient requirements existed among the lines was provided by studies involving the quantitation of feed intake. Both fast growing lines were more efficient in the conversion of feed than were the slow growing lines. However, when birds of the fast growing lines were fed the same quantity of feed as that consumed by the slow growing lines, no difference in growth was noted. The data indicates that selection for growth rate on a methionine deficient diet is accomplished through genetic differences in appetite and not through changes in requirements. (AH el-52)

3. Selection for egg production under sub-circadian periodicities. Data obtained from the second generation of White Leghorns selected for egg production under 18-hour "short days" differed only slightly from that obtained from the initial generation. Percent hen-day egg production was

1.3% greater than the previous year and 3% above the randombred controls. The percent hen-day production of the 24-hour control population was 1.8 and 2.3% superior to the previous generation and the randombred controls, respectively. Differences noted in the second generation between the 18-hour and control population were small for all traits except 8-week body weight and age at first egg. Birds in the 18-hour population were 40 grams heavier at 8 weeks and matured 11 days later than those in the 24-hour control population. Two light treatments (constant and step down) were superimposed during the growing period on the 18-hour population during the first two generations. Differences were small and not significant for percent hen-day production, 20-week body weight and 320-day body weight. Eight-week body weights were higher for the step down group, while birds reared on the constant photoperiod matured 7 days earlier. A study utilizing the Coturnix quail under the same two environments was initiated during the year to determine if these birds respond to selection programs in a manner similar to chickens. The data available after the completion of the first generation, from the two 144 bird populations, serves only as an indication of the comparative performance of birds maintained under the 18-hour cycle as opposed to the 24-hour controls, since no genetic selection has been introduced up to this point. The hen-day egg production over the 90-day laying period was 70 and 67% for the control and 18-hour population, respectively. This difference was not significant. (AH el-47)

4. Genotype-environment interactions. Genotype-environment interaction studies with both egg and meat production stocks were conducted as a part of the Southern Regional Poultry Breeding Project. Data analyzed to date indicate that the performance of both meat and egg production stocks is influenced by interactions of genotype and the environment. Further analysis of the data is being completed to assess the magnitude and importance of the interactions relative to the total observed variation. (AH el-44)

5. Genetic variation in chemical or physiological traits. Selection for resistance and susceptibility to gonadotropic hormone inhibition in lines developed from the Regional Cornell Control was continued at the Southern Regional Poultry Genetics Laboratory. Data from the first selected generation were analyzed to estimate the heritabilities and the genetic and environmental relationships of inhibition and production traits. Results indicate that the heritability of days of inhibition estimated from the sire component of variance was approximately 0.30. The corresponding value for pretreatment egg production was 0.21. Genetic correlation estimates between the two traits were approximately -.49, indicating that indirect selection for resistance to inhibition would not be as efficient in selecting for egg production as selection for the trait directly. (AH el-50)

Following six generations of selection at the Maryland Station for high and low serum cholesterol at six weeks of age the cholesterol level of the high line was approximately thirty percent greater than that of the low line. The heritability of serum cholesterol level was calculated to be .25 in a

randombred population. The high cholesterol line had lower juvenile weight and lower blood pressure, but higher egg albumen quality, than did the low line. There were no consistent, statistically significant, differences between the lines with respect to productive traits or in yolk cholesterol. Liver synthesis of cholesterol was equivalent in the two lines but fecal excretion of the metabolite was greater in the low line. (AH el-45)

Positive and negative selection at the New Jersey Station for blood pressure in two lines of chickens produced a difference of 56 between males of the two lines and 44 between the females after five generations of selection. Levels of blood pressure in the two lines was not associated with mortality among the males but mortality was greater in hypotensive than in hypertensive females. A similar situation was found with respect to the abilities of the birds of the selected lines to withstand exercise stress. In general, the biological efficiency of the birds was better in the high pressure line than in the low pressure population. The heritability of systolic blood pressure was estimated at approximately .27. (AH el-45)

6. Genetic variation in economic traits. At the Georgia Station comparisons were made between two populations of randombred controls differing in genetic base. Results from the second generation of divergent selection for 8-week body weight in each population indicate that the total response between the high and low lines of the narrow base population was 93.1% of the progress made in the broad base population. Similar results were observed in generation one. (AH el-44)

In a test at the New Hampshire Station of recurrent versus closed flock selection for improving broiler qualities there was no evidence that a cross-line progeny test had any advantage over a pure line progeny test for improving 8-week body weight within a line. Cross-bred progeny of 4th generation males from the two selected lines mated to randombred females were heavier from the recurrent line than from the closed line but not significantly so. (AH el-45)

In selection experiments at the Oregon Station with Broad Breasted Bronze turkeys, first generation low libido line males were less responsive in individual and group comparisons of aggressive mating behavior than the high libido and random lines males. During the first four weeks of egg production the receptivity of high libido line females was higher than for females of the other two lines. In twenty 30-minute observation periods during the four weeks, high libido line females completed an average of 3.5 matings per hen as compared to 1.8 and 1.9 for the low libido and random lines females. The fertility following natural matings with random line males averaged 59.5, 39.6 and 44.7% for the high libido, low libido, and random lines. With later matings by artificial insemination within lines the eggs averaged 93.3% fertile, with no differences between lines. Body weight and conformation measurements indicated there were no differences between lines due to selection for libido. (AH el-46)

7. Genetics of shell pigmentation in Japanese quail. An autosomal recessive mutation which, in the homozygote, results in almost complete lack of egg shell color has arisen in the colony of Japanese quail (*Coturnix coturnix japonica*) maintained by Poultry Physiology Investigations. All F₁ female progeny of white-egg hens mated to randombred normal males lay normally pigmented eggs. Matings of F₁ males and females produce normally pigmented and white-egg females in a 3:1 ratio. Backcross matings of F₂ white-egg females to F₁ males produce normally pigmented and white-egg female progeny in a 1:1 ratio. Males homozygous for the white-egg trait have been identified by test matings of male backcross progeny with white-egg females. A purebred white-egg breeding colony, producing 50-75 progeny weekly, has been established. The usefulness of the Japanese quail as an experimental animal has been broadened by the establishment of the white egg strain. Pedigree markings on the white shell can be read with far less chance of error, and accurate staging by candling can now be accomplished for quail embryos as easily as for chick embryos. Considerable interest in obtaining the white egg strain has been expressed by a number of geneticists, physiologists, and virologists throughout the United States. (AH e3-22)

B. Selection and Systems of Breeding.

1. Evaluation of genetic changes produced by various breeding systems. The evaluation of breeding systems and selection methods was continued at five stations and at the central facilities of the North Central Regional Poultry Breeding Laboratory. Three randombred control populations are maintained and made available to cooperators as foundation stock and controls. Eggs from these control stocks are shipped to many locations throughout the country upon request. Selection at each station is for one trait, hen-day percent egg production to about 300 days of age. Other traits are recorded but are not the basis for selection. Selection pressure is maintained at approximately 25% for both male and female progeny.

At the Indiana Station, closed flock index selection and reciprocal recurrent selection in Cornell White Leghorns and Purdue Pool populations were continued and crosses of the index and reciprocal recurrent selection populations were tested. Two generations of selection have been tested. Results of these tests indicate little or no gains in hen-day percent egg production from selection based on individual, sire and dam family means (index) or reciprocal recurrent selection.

At the Kansas Station, a study of index and reciprocal recurrent selection was continued on foundation stocks of Cornell White Leghorns and Rhode Island Red Regional Controls, and their crosses. After three generations of selection, all index selected populations were above the controls when comparisons were made based on deviations of selected populations from controls. Reciprocal recurrent selected populations showed no increase

over the controls. Unselected traits generally showed little change from the controls.

The Missouri Station has completed four generations of selection for percent egg production using both recurrent selection to inbred testers and index selection. The females used in both of these breeding methods and also the males in the index selection were from the randombred control populations. The inbred tester lines used as the male parent in the three recurrent selection populations consisted of a White Leghorn, a White Plymouth Rock and a Rhode Island Red line. A White Leghorn flock selected on the basis of an overall performance index is designated as the intra-flock population.

The intraflock population and crosses had essentially the same hen-day percent egg production from first egg to 64 weeks of age, as the selected randombreds. The above populations exhibited slightly better production than the randombred controls. After four generations, two of the recurrent selection lines show no indications of an increase in production, while in one recurrent selection line production is somewhat higher.

Twelve inbred lines, of Regional Cornell Control stock, were continued at the South Dakota Station through 1963. Six of these lines (three selected and three random) have provided sires for pullets which are currently being tested at three substation locations. At a fourth location, one of the selected inbred lines provided sires for one of the five pens of test pullets. The performance of pullets from selected and from random inbred sires were compared with each other and with other mating types in the 1962-63 tests. At one location the pullets from selected inbred sires performed better than did the purebreds and those from random inbred sires. Age at maturity, mortality, egg size, and adult body weight were similar for the three groups. Broodiness and maturity varied somewhat at the different stations.

Samples of 45 populations with three replications of each were compared, under standard environmental conditions, at the North Central Regional Poultry Breeding Laboratory. Sixteen economic traits were measured on 3,700 birds. The Regional Cornell Randombreds, on which 17 selection systems are based, remained relatively stable in all traits at the completion of six generations of random mating. Ten of the systems were superior to the base population in hen-day percent egg production; however, none of these differences reached statistical significance at the 5% level. The sire family selection system with half and full-sib matings was significantly lower than the controls as expected. The sire family selection system with restricted inbreeding and the dam family selection system were not different from the controls. The individual selection system was below the controls, but the difference was not statistically significant. In general, index selection using individual, sire and dam family records ranked high when compared to the other methods of selection; however, most of the effects of selection occurred in the first generation. For the

first time, the selected populations generally ranked below the controls in egg weight. This may be due to a reversal in the downward trend in egg weight that had previously been shown by the control populations. (AH el-43)

An analysis of diallel crosses of four light and four heavy type inbred lines was conducted by the Purdue Station under a Research and Marketing Act contract. The results indicate that cross x year interactions were not important in the inbred lines, but contributed significant effects in the single and double crosses. The presence of a cross x year interaction reduced the efficiency of predicting single and multiple cross performance. In general, the variation due to general combining ability effects among the crosses was larger and more important than reciprocal or specific combining ability effects. The prediction of single cross and top cross performance from knowledge of the inbred lines was low when multiple R^2 values were used, whereas parent-offspring regressions suggest that adequate predictions are feasible. (Research and Marketing Act Contract No. 12-14-100-5763 (44)).

2. Rancombred control populations. Five rancombred control populations are maintained for use as genetic and environmental controls and as a gene pool for use in initiating new research. Three stocks are maintained at Lafayette, Indiana, primarily for egg production research and two at Athens, Georgia, for meat production research. Hatching eggs from these populations are supplied to research workers at experiment stations, to random sample tests and to commercial poultry breeders. (AH el-43, AH el-44)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Genetics and Interrelations of Performance Traits

- Becker, W. A. 1963. Pre-incubation storage of turkey eggs and its effect on body weight. Poultry Sci. 42:1356-1359. (AH el-46)
- Becker, W. A. and Bogyo, T. P. 1963. Heritability of developmental time and viability of turkey embryos in three environments. Proc. XI Int. Cong. Genetics, Vol. 1:153-154. (AH el-46)
- Bogyo, T. P. and Becker, W. A., 1963. Exact confidence intervals for genetic heritability estimated from parental half-sib correlations. Biometrics 19:494-496. (AH el-46)
- Cook, R. E., Hess, C. W., and Dembnicki, E. F. 1963. Importance of genotype-environment interactions in egg production stocks. Poultry Sci. 42:1261-1262. (AH el-44)
- Friars, G. W., Bohren, B. B. and McKean, H. E. 1963. Time trends in estimates of genetic parameters in a population of chickens subjected to multiple objective selection. Poultry Sci. 4:1773-1784. (AH el-43)
- Gutierrez, J. H. 1963. Genetic and physiological responses of the domestic fowl to progesterone treatment. M.S. Thesis, University of Georgia. (AH el-44)

- Harris, P. C. and Wilcox, F. H. 1963. Studies on egg yolk cholesterol.
1. Genetic variation and some phenotypic correlations in a random bred population. Poultry Sci. 42:178-182. (AH el-45)
- Harris, P. C. and Wilcox, F. H. 1963. Studies on egg yolk cholesterol.
2. Influence of season. Poultry Sci. 42:182-185. (AH el-45)
- Harris, P. C. and Wilcox, F. H. 1963. Studies on egg yolk cholesterol.
3. Effect of dietary cholesterol. Poultry Sci. 42:186-189. (AH el-45)
- King, S. C., VanVleck, L. D. and Doolittle, D. P. 1963. Genetic stability of the Cornell randombred population of White Leghorns. Genetic Res. 4:60-74. (AH el-45)
- Marks, H. L. and Lucas, L. M. 1963. Time of oviposition under "short days." Poultry Sci. 42:1466-1468. Abstract. (AH el-47)
- Poole, H. K. 1964. Egg shell pigmentation in Japanese quail. Genetic control of the white egg trait. Journal of Heredity, Vol. 55:136-138. (AH e3-22)
- Saadeh, H. K. 1963. Non-additive genetic variation, maternal effect and genotype x environment interaction effect as estimated from the body weight of chickens. Unpublished M.S. thesis. University of New Hampshire Library, Durham, New Hampshire. (AH el-45)
- Van Vleck, L. D., King, S. C. and Doolittle, D. P. 1963. Sources of variation in the Cornell Controls at two locations. Poultry Sci. 42:1114-1125. (AH el-43)
- Weinland, B. T., Carson, J. R., and King, S. C. 1964. Stability of gene frequencies in a randombred control population of chickens. Poultry Sci. 43:985-990.
- Wilcox, F. H., Cherms, F. L., Jr., VanVleck, L. D., Harvey, W. R. and Shaffner, C. S. 1963. Estimates of genetic parameters of serum cholesterol level. Poultry Sci. 42:37-42. (AH el-45)
- Wilcox, F. H., Shaffner, C. S. 1963. Performance of lines selected for high and low cholesterol, Poultry Sci. 42:1033-1035. (AH el-45)

Selection and Systems of Breeding

- Abplanalp, H., Ogasawara, F. X., Asmundson, V.S. 1963. Influence of selection for body weight at different ages on growth of turkeys. British Poultry Science 4:71-82. (AH el-46)
- Morgan, W. and Kohlmeyer, W. 1963. Inbreeding with and without selection. Genetics 48:902. (AH el-43).
- Ogasawara, F. X., Abplanalp, H. and Asmundson, V. S. 1963. Effect of selecting turkeys for increased body weight on reproduction in turkey hens. Poultry Sci. 42:838-842. (AH el-46)

AREA NO. 9: POULTRY - PHYSIOLOGY

Problem. Continuing basic research in avian physiology is essential to establish fundamental concepts and to increase the knowledge upon which ultimately must depend the solution of such problems as fertility, hatchability, growth and egg production. Basic physiological knowledge is necessary also for implementation of the subject matter of other disciplines. In reproductive physiology, for example, the dominant role of the central nervous system is now generally recognized, but much intensive research will be required before we can expect any "useful" knowledge of mechanisms by which the varying actions of external and internal factors are integrated and directed to initiate, maintain or modify reproductive functions. Many aspects of environmental physiology, of responses to stress, and of growth and development likewise depend upon basic research. On the more immediately practical side, increased knowledge of poultry housing, related equipment and other management factors is necessary to provide optimal ranges of operational efficiency.

USDA AND COOPERATIVE PROGRAM

This is a continuing program, mainly on basic aspects of the physiology of avian reproduction, but including also applied studies pertaining to environmental physiology and management. In addition to physiologists, the work draws upon geneticists and animal husbandmen. Research is in progress at Beltsville, Maryland, and Glendale, Arizona, the work at Glendale contributing to regional project W-50. Cooperation currently is maintained with members of the Farm Electrification Branch, AERD; Bellevue Hospital, New York City; the National Institutes of Health; and Pennsylvania State University. Federal research in this area calls for 7.4 professional man-years, distributed to subareas as follows: Physiology of reproduction, 4.4; environmental physiology, 2.1; physiology of growth and development, 0.5; and program leadership, 0.4.

PROGRAM OF STATE EXPERIMENT STATIONS

Research is concerned with the basic aspects of the physiology of growth, reproduction, fertility and hatchability in chickens and turkeys as well as applied aspects pertaining to environmental physiology and management. Fundamental research is in progress to elucidate the role of the nervous system and the endocrine system in controlling ovulation and oviposition in poultry. Investigations are being conducted on the physiology of sperm in order to develop techniques for storage and to dilute semen without reducing fertilizing capacity for use in artificial insemination.

The states of the Western region and the USDA are cooperating through Regional project W-50 to study the effect of different combinations of light, temperature, altitude and other environmental factors on

reproductive performance of the chicken. Some stations are investigating the effect of light and temperature on thyroid gland function, the influence of wave length of light upon growth and production, the effect of amount of light per day or light intensity during the growing period on subsequent reproductive performance in the female.

The field of poultry behavior is being investigated and includes such activities as imprinting, cannibalistic behavior, sexual behavior and social organization of the flock.

Consideration is given to the influence of male hormones on embryonic development of the bursa of Fabricius as it affects antibody production of chickens in the immediate and future generations.

Investigations into embryonic mortality and hatchability in relation to growth and development are underway. These studies are concerned with the effects of embryonic irradiation exposure upon subsequent life span, the establishment of optimum level of gases in the incubator atmosphere for normal embryonic development and investigation of mechanisms by which the embryo utilizes the components of the egg.

Research is underway on the circulatory system and involves physiological studies on the heart and factors concerned with blood pressure regulation.

The total State scientific effort devoted to poultry physiology research is 46.6 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction.

1. Neuroendocrinology. Work was continued with the chicken on the effects of mechanical stimulation of the brain on oviposition. Any of several brain manipulations causes premature lay of the terminal egg of a recurrent 2-egg sequence to occur within a specific 2-hour period on the morning of normal lay. This almost certainly means that the time of premature lay is governed by diurnal periodicity in some undetermined physiological state of the hen. Preliminary efforts were made to establish some of the factors involved in the phenomenon of diurnally restricted premature lay.

Current fragmentary knowledge of the control of oviposition indicates that lay results from the abrupt release of neurohypophyseal hormone(s). An initial experiment was therefore undertaken to establish whether premature lay resulted from an earlier release of hormones from the posterior pituitary. Following the development of a routine useful technique for neurohypophysectomy, the effects of removal of the posterior pituitary on normal and induced oviposition of the terminal egg were compared. Surprisingly, elimination of the posterior lobe did not delay or prevent

normal lay of the terminal egg (C_t) of the cycle, nor of C_1 lay induced by brain stimulation. The results suggest two mutually exclusive conclusions: (1) Neurohypophyseal hormones play no essential role in oviposition in chickens or (2) the posterior pituitary serves only as a non-essential storage depot for the effective hormone and all of the basic machinery for the production and release of this hormone is present in the components of the hypothalamus-hypophyseal system proximal to the posterior lobe. The first premise would be extremely difficult to test by available experimental methods. The second possibly, however, can now be tested by classic physiological techniques applied to the neurohypophysectomized hen.

Penultimate ovipositions of the hen's sequence are generally thought to be subject to controls which are lacking or inoperative during lay of the terminal egg. To test the possible influence of these factors on premature lay, a comparison was made of the effects of brain stimulation on the first and last ovipositions of the 2-egg sequence. Basic differences were noted in the type of mechanical stimulation required to induce lay, in the times of effective stimulation, and in the hours of premature lay. Premature C_t lay could be induced by the insertion of electrodes into the cerebral cortex, median thalamus or preoptic brain, but C_1 lay (first egg of the cycle) could be forced only by insertion of preoptic electrodes. As tested by placement of electrodes in the preoptic brain, stimulation during the period of 9 P.M. to midnight on the night before lay proved most effective for premature C_1 lay, while stimulation during the hours of 6-9 A.M. on the morning of expected lay was most effective for C_t lay. Nearly all premature C_1 ovipositions occurred between 6 and 8 A.M., while premature C_t lay, as in earlier experiments, was restricted to the hours of 10 A.M. to noon. The physiological basis for the observed difference in response between the first and last eggs of the sequence remains to be elucidated. Evidence from other sources indicates that factors associated with release of ovulating hormone from the pituitary and/or ovulation are involved.

It has been proposed recently that the processes of urine excretion and egg shell formation compete for calcium and that this is the basic cause of reduced shell thickness in the summer months. According to the theory, increased water consumption in hot weather leads to increased urine output, thereby reducing the amount of calcium available for shell formation. The theory was tested in neurohypophysectomized chickens held under stable conditions of temperature and humidity. Neurohypophysectomy causes severe polydipsia and polyuria, but does not permanently interfere with egg production. In this experiment shell thickness in eggs laid by neurohypophysectomized hens did not differ significantly from shell thickness of eggs laid by the same hen before lobectomy even though water consumption and urine excretion were increased by 2 to 5 times the preoperative levels. The results offer strong evidence that some temperature related factor other than urinary excretion of calcium is responsible for reduced shell thickness. (AH e3-21)

The hen's coupled ovulation cycle includes a single day of lapse between ovulations or sequences of consecutive daily ovulations. The uncoupled cycle follows a lapse of two or more days. In coupled cycles, the release of gonadotrophic hormone (GTH) for ovulation of the terminal follicle (C_t) of one cycle appears also to evoke maturation of the first or C_1 follicle of the succeeding cycle. As the number of members (n) in coupled cycles increases from 1 to about 7, the release of GTH for maturation of the C_1 follicle occurs at progressively later hours. On theoretical grounds, it seemed improbable that the time of GTH release for maturation of the C_1 follicle of uncoupled cycles could be subject to factors believed to account for the progressively later times of release appearing in coupled cycles. Examination of the conditions under which the uncoupled GTH release takes place led to the surmise that release might occur during a diurnally recurrent "critical period" falling at about the hour of the C_1 maturation release in lengthy coupled cycles. If this were so, it seemed likely that first ovipositions of uncoupled cycles of low n would occur somewhat later in uncoupled than in coupled cycles, and that the difference would decrease as n increased. Times of ovipositions were therefore compared in coupled and uncoupled cycles of 1, 2 and 3 members. In a selected group of White Leghorn hens, first ovipositions were found to occur 46 minutes later in uncoupled 1 member cycles, 19 minutes later in 2 member cycles and 4 minutes later in 3 member cycles. These differences, and notably the order of differences, are in accord with the view that the neural component of the GTH release mechanism exhibits, at the uncoupled C_1 maturation release, a 24-hour periodicity or "critical period" which appears in a constant relationship with some phase of photoperiod. It is suggested that the varied patterns of timing seen in GTH release cycles are imposed upon this fundamental 24-hour periodicity by feedback hormones of ovarian origin.

2. Parthenogenetic reproduction. Parthenogenetic development in chicken and turkey eggs is characterized by its slowness in getting underway once the eggs are placed within the incubator. The underlying cause for this delay is believed to represent the time required for highly disorganized cells to regroup so as to form a normal blastoderm. To get more precise information on the degree of variability existing among parthenogenetically developing eggs, the following tests were conducted.

Newly laid, unfertilized turkey eggs were incubated at 99.3° F. and 100 eggs were removed and broken after having been incubated 24, 48, 72, 96, 120 and 144 hours, respectively. Each blastoderm was examined macroscopically and data collected on the growth (diameter) attained by each developing disc.

Much variation was found among eggs of each age group in the numbers and sizes of developing blastoderms. Only one of the 100 eggs examined at 24 hours of incubation had a developing blastoderm. The marked change occurred between 24 and 48 hours of incubation, during which time 35 eggs showed evidence of parthenogenetic development. There were no significant changes in the number of developing blastoderms during subsequent periods of

incubation. Twenty-seven, 44, 41, and 27 developing blastoderms were encountered in eggs at 72, 96, 120, and 144 hours of incubation, respectively.

Variability in sizes of developing blastoderms within groups became more pronounced as incubation progressed. For example, 21 developing blastoderms at 96 hours and 11 at 120 hours of incubation had attained diameters equivalent to 12 to 24 hours normal development. However, developing blastoderms of other eggs within these same age groups were far more advanced, having attained stages of growth at which membranes covered the entire surface of the yolk. Several of these more advanced blastoderms had given rise to parthenogenetic embryos about the size of 2 or 3 day normal embryos.

A cooperative study with Dr. Frank Raucher, NIH, was initiated to determine (1) if dissociated parthenogenetic cells of turkey eggs could be induced to develop on the chorio-allantoic membranes of chicken and turkey eggs and (2) if these embryonic cells still retain the ability of giving rise to embryos. The possibility of parthenogenetic embryos arising from individual cells was suggested by studies of twinning, in which a high incidence of multiple embryos were encountered in unfertilized turkey eggs.

Turkey embryonic cells of parthenogenetic origin, on being dissociated with trypsin were placed on the chorio-allantoic membranes of 10 day chicken and turkey embryos and injected into the body cavities of 4 day old turkey poults. No embryoid-like structures were found following the inoculation of eggs or poults. (AH e3-19)

3. Homograft reactions. Last year's report presented evidence that histocompatibility antigens can be present in skin grafts from male turkey parthenogens which are not present in their progeny by unrelated females, and it was concluded that these parthenogens were heterozygous at segregating genetic loci assumed to control expression of histocompatibility antigens. However, the possibility remained that a "maternal effect" could have been responsible for the incompatibility since the parthenogenetic sires and their progeny had different dams. Subsequently, two parthenogens were mated, each to his own dam, and produced seven and four backcross progeny, respectively. A wattle skin graft was transplanted from each sire to each of his own progeny. Four of seven and two of four backcross progeny rejected their respective sires' skin. Grafts to the remaining progeny have survived permanently. These results are additional strong evidence of heterozygosity at histocompatibility loci in turkey parthenogens and appear to exclude the possibility that "maternal effects" were the cause of the graft rejections reported previously. (AH e3-20)

4. Estrogen-modified sex in turkeys. Three hundred micrograms per egg of estradiol benzoate in corn oil were injected into Beltsville Small White turkey eggs on the second day of incubation. Controls included uninjected and corn oil injected eggs. Hatched poults were autopsied at hatching 4, 6,

16, and 35 weeks of age. No morphological abnormalities were observed in the control groups at any age. Embryonic and posthatching mortality was high in the estradiol injected group. Effect on genetic females was generally one of hyperfeminization, specifically hypertrophy of Mullerian ducts. Intersexes were noted at all ages. The combined number of intersexes and normal males approximated the number of females and led to the assumption that the intersexes were genetic males. They exhibited a range of modifications from small, cystic testes or complete gonadal suppression (agonadal birds) to formation of an ovotestis. Mullerian ducts were present in varying degrees of development in some but not all intersexes. The observations indicated initial severe feminization of genetic males followed by either gonad suppression or regression toward genetic sex type (ovotestis formation). There was no evidence of complete or permanent sex reversal with this estradiol benzoate treatment.

B. Environmental Physiology.

1. Water starvation in poults. In June 1963, heavy losses were sustained in young Beltsville Small White poults after they had drunk water avidly following failure to find their drinking water during an estimated period of about 48 hours. No pathology was found in the dead birds. In a series of experiments following this loss, it was shown that, after water deprivation periods of 48 to 52 hours, the rapid ingestion of water was followed promptly by mortalities of 60 to 100% in poults 11 or 18 days of age. Following a deprivation period of 24 hours, mortality in 18-day old poults was 40%, but poults 11 days of age were unaffected as were poults 3-1/2 to 11-1/2 weeks old subjected to waterless periods of 24 to 52 hours. Attempts to return water-starved poults gradually to full water consumption were unsuccessful. These findings suggest a possible explanation for some of the mortality that occurs frequently in young poults in the absence of any gross pathology. They also emphasize the need for care in making changes in the method of supplying drinking water to young poults to insure continued consumption without long periods of deprivation. (AH e3-18)

2. Controlled photoperiods in chickens. Experiments have continued at Glendale, Arizona, on the effects of controlled light of various patterns during the growing period on subsequent egg production of October-hatched White Leghorns. Regardless of the light patterns and regimens used during the growing period, age at sexual maturity was delayed and egg size remained greater with a decrease from natural light. With an increase over natural light, sexual maturity was hastened and egg size remained smaller. Using a step-down light pattern during the growing period and a step-up pattern during the laying period resulted in delayed sexual maturity and larger egg size, but effects on total egg size were contradictory. (AH e3-16)

3. Comparison of caged and floor-housed pullets. At Glendale, Arizona, individually caged pullets laid slightly fewer eggs and experienced slightly greater mortality than did pullets maintained on litter floors. Pullets housed 5 in 24 by 18 inch cages laid fewer eggs than did birds housed

individually in 8 or 10 by 18 inch cages. Mortality, due mainly to vent picking, averaged 34 percent for group caged pullets against 8 percent for individually caged birds. Cutting back both mandibles or including a tranquilizer in the diet did not appreciably lower mortality in the pullets housed 5 to a cage. In comparing population density on litter floors, birds maintained one per 3 square feet produced a few more eggs with lesser mortality than did those maintained on 1-1/2 square feet each. Pullets on slat floors laid substantially fewer eggs and consumed more feed than did birds on litter. Both eggs and feed were lost through the slat floors. (AH e3-17)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

- Fraps, R. M. 1964. Follicular maturation and diurnal periodicity in the hen's ovulation cycle. Proc. Endocrine Soc., 46th Meeting, p. 87. (Abs.)
- Opel, H. 1964. Premature oviposition following operative interference with the brain of the hen. Endocrinology, 74, 193-200. (AH e3-21)
- Poole, H. K. 1963. Some effects of estradiol benzoate on development of the reproductive system of the turkey. British Poul. Sci. 4, 279-284. (AH e3-20)
- Poole, H. K. 1963. Observations on the chromosomes of turkey-chicken hybrids. J. Heredity, 54, 101-102. (AH e3-20)

Environmental Physiology

- Lowe, R. W. and Heywang, B. W. 1964. Effect of various light treatments during the growing period on egg production of October-hatched White Leghorn pullets. Poultry Sci. 43, 11-15. (AH e3-16)
- Marsden, S. J. and Lucas, L. M. 1964. Effect of short-day or low-intensity light treatments on reproduction of fall-hatched turkeys in two environments. Poultry Sci. 43, 434-441. (AH e3-18)

AREA NO. 10: POULTRY - NUTRITION

Problem. The goal of nutrition research is to amass information so that poultry diets may be formulated and fed to produce the best quality product at the least possible cost. The problem logically divides into two areas: (1) furnishing the nutritive requirements of poultry, and (2) the feedstuffs that supply these requirements. A refined methodology is needed to estimate more accurately the energy (carbohydrates and fats), protein (amino acids), vitamin and mineral requirements of poultry of various ages, strains and levels of production. Even more urgently needed is information on the relationships that exist between these nutrients, if the formulation of optimum nutritive balance in diets is to be attained. Additional information is required on the effect of feed additives (antibiotics, arsenicals, hormones, enzymes, antioxidants, tranquilizers) on nutritive requirements, and on the utilization of protein and energy. Somewhere in the maze of requirements, interrelationships and interactions, it must be determined which portion of the diet is for intestinal microorganisms and which is for the host. Also, the vast field of interrelationships between disease and nutrition remains to be explored. In the feedstuffs area, how much of a particular nutrient that is present should be known, but of more importance is how much is available to the bird. Thus, information on digestibility, absorption, chelation and interactions is necessary. In addition, the complete composition of a feedstuff must be known. At the present, the proximate analysis is the only information available about major dietary constituents; consequently, the nutritionist does not know exactly what is being fed when a diet is formulated. There may be present growth promotant and/or inhibitors of which he is not aware.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by nutritionists on basic and applied research on the nutritive requirements and digestion and metabolism of poultry and the nutritive value of feedstuffs. The work is in progress at Beltsville, Maryland, and at the Southwest Poultry Experiment Station, Glendale, Arizona. Some phases of work at Glendale are carried on in cooperation with the Departments of Biochemistry and Poultry Science of the University of Arizona at Tucson. Studies concerned with the influence of different factors on the metabolism of vitamin A in chickens are in progress at the Hebrew University, Israel. Its duration is for three years, 1962-1965, and involves PL 480 funds. (A10-AH-7)

A project for the evaluation of the protein quality and energy values of feedstuffs available in India is in progress at Punjab Agricultural University, Ludhiana, India. Its duration is for five years, 1964-1969, and involves PL 480 funds. (A7-AH-21)

The Federal effort devoted to research in the poultry nutrition area totals 6.7 professional man years. Of this number 2.0 are devoted to digestion and metabolism, 1.6 to nutritive value of feeds, 1.7 to protein and energy requirements, 1.0 to other nutritive requirements, and 0.4 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

Research is being conducted on the chicken and turkey requirements for specific amino acids, minerals, vitamins, energy and unidentified growth factors for maintenance, growth, egg production and health.

The mineral studies are concerned with trace mineral requirements and the interrelationship of calcium, phosphorus and vitamin D associated with bone calcification and egg shell quality. The detrimental effect of high levels of dietary calcium on hatchability of turkey eggs is being studied. The influence of specific polyunsaturated fatty acids on egg size and cholesterol metabolism as well as protein and energy requirements and interrelationships are being investigated. In addition to the establishment of requirements, vitamin research is concerned with the role of vitamin E in encephalomalacia and vitamin K in blood clotting mechanisms.

The effect of alfalfa, anticoagulants and vitamin K on the incidence of blood spots in eggs is being studied. Only a limited amount of research is being conducted on unidentified growth factors. Sources of xanthophyll pigments are being evaluated as economical sources of broiler pigments. Studies are being conducted on the nutritive value of locally grown feed-stuffs and methods of increasing the availability of starch and protein by chemical, physical and enzymatic treatment. New antibiotics are being evaluated for growth promoting ability, but only limited research is being conducted on the mode of action of antibiotics on growth promotion.

Management. Intensified methods of production are resulting in changes in management practices. Broiler studies are concerned with the effect of heat stress and floor space on growth rate and feed efficiency. The reproductive performance of chickens as affected by light or feed restriction during the growing period, housing density in floor pens or cages and temperature stress are being investigated. Studies on floor, feeder and water space needs and litter and housing practices for efficient turkey production are being conducted.

The total State scientific effort devoted to poultry nutrition and management is 55.4 man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Nutritive Requirements.

1. Vitamin requirements. Studies at Glendale, in cooperation with the

University of Arizona, in which White Leghorn pullets were fed stabilized vitamin A at levels ranging from 250 to 3,000 USP units per pound of diet showed that 1,250 USP units were adequate for maximum production, feed conversion, fertility and hatchability. Adequate vitamin A intake during growth has considerable influence on subsequent performance since pullets raised on minimum levels did not produce as well as those raised on adequate levels. The lowest incidence of blood spots in eggs was found at the highest level of vitamin A intake.

Experiments were conducted at Glendale and the University of Arizona to determine the vitamin A requirements of chickens grown in a subtropical, semiarid climate. The results indicate that when vitamin A was increased from 500 to 3,000 USP units per pound of diet there was no significant improvement in growth rate and feed conversion to 10 or 20 weeks of age. In all of the tests there was an increase in vitamin A stored in the liver as the level of the vitamin in the diet was increased. Chickens reared during the cooler periods stored more vitamin A in the liver than those reared during hot weather. Studies at Glendale in cooperation with the University of Arizona showed that sodium ascorbate fed to White Leghorn layers at levels of 10, 20 and 454 mgs. per pound of feed, had no appreciable effect on egg weight, shell thickness, or ratio of dried shell weight to whole egg weight. (AH e2-15)

2. Mineral requirements. In continuation of the study of calcium and phosphorus requirements of broiler chickens, a fourth test was conducted in an effort to refine the requirement values and, in particular, to determine with more accuracy the upper level of the range of calcium adequacy. The trial was with mixed sexes, and involved calcium levels of 0.75, 0.80, 0.85, 0.90 and 0.95%, and total phosphorus levels of 0.6, 0.65, 0.70 and 0.75%. The results indicate no significant difference in growth response to calcium levels between 0.8 and 0.95% on all phosphorus levels. It was clearly indicated that phosphorus levels of 0.70% and above resulted in depression in growth rate and decrease in efficiency of feed utilization. The results of the four studies, involving over 25,000 chickens, show that under practical conditions, the optimum dietary levels of these minerals for maximum performance are 0.80-0.85% calcium and 0.60-0.65% total phosphorus. This phase of investigation of mineral requirements is completed. (AH e2-18)

3. Fat requirements. In continuation of studies concerned with the effect of linoleic acid deficiency on reproductive performance, Leghorn females were reared on a linoleic acid-free diet. At maturity, the pullets were distributed into six groups and groups one through six were maintained on the deficient diet, plus 0, 10, 20, 40, 80, or 250 mg. linoleic acid/day/hen, respectively. Egg production, egg size, and hatchability paralleled the increase in dietary linoleic acid with the exception of zero hatchability for groups 1 and 2. Egg production, egg size, and hatchability in group 6 did not equal that of hens on a practical diet, indicating that 250 mg. linoleic acid/day/hen was insufficient for optimum

performance. There is an indication that the severe depletion resulted in irreparable damage to the hens, or that the diet was lacking in some nutrient other than linoleic acid. When the depleted hens received linoleic acid equal to that in the practical diet, egg production, egg size and hatchability increased, but after a two-month period were not equal to that of the practical diet. No linoleic acid could be detected in the yolk fat of eggs from hens maintained on linoleic acid-free diet. It was present only in trace quantities in the yolk fat of eggs from hens receiving 40 mg. or less of the acid/hen/day after 20 weeks. As the linoleic acid content of the yolk fat increased there was a concurrent decrease of the C-20 triene.

In experiments to determine the fat and fatty acid requirement of Coturnix quail, it was found that the growth rate of quail on a purified isolated soy protein diet was improved by the addition of corn or safflower oil; however, linoleic acid failed to increase growth rate equivalent to that of the intact oils. The purified diet supplemented with oil did not support growth comparable to that obtained with practical diets. The linoleic acid content of the tissues of quail on diets deficient in this fatty acid were reduced, but not to the same extent as comparable tissues of all chicks deficient in linoleic acid. (AH e2-13)

B. Digestion and Metabolism.

1. Metabolism of fats. Studies to determine the effect of fat depletion of laying hens on the growth rate and fatty acid composition of their progeny were conducted. Depletion of the hens for 16 weeks did not affect the growth rate of the progeny, but after the hens had been depleted of essential fatty acids for 32 weeks the growth rate of their progeny was significantly lower than the progeny of hens fed fat in their diets. Essential fatty acid depletion of these hens resulted in a reduction of the level of polyunsaturated fatty acids and an increase in monounsaturated fatty acids in the plasma and heart fat of the progeny. During the depletion period, the linoleic acid levels decreased more rapidly than the arachidonic acid level in the plasma and heart fat of the progeny. The chicks from hens on the fat-free diet were late in hatching, and had a lower level of linoleic and arachidonic acid and a higher level of C-20 triene than chicks from hens receiving dietary fat.

Experiments concerned with increasing the hatchability of eggs from linoleic acid deficient hens by injection of linoleic acid or methyl linoleate into the yolk resulted in no improvement in hatchability. This indicates that the developing embryo is unable to utilize free fatty acids.

Studies to determine the effect of dietary linoleic acid deficiency on the reproductive performance of male chickens showed that the lack of this fatty acid resulted in decrease in semen production and in fertility. Fatty acid analysis of the semen showed a low linoleic acid content compared to other tissue for both linoleic acid deficient and normal males. The semen

of normal males contained about ten times as much linoleic acid as that from the deficient males. Two unidentified fatty acids were observed, one of which was much higher in the deficient males, and the other higher in the normal males. (AH e2-13)

2. Utilization and function of vitamin A. Studies on the function and utilization of vitamin A at the Hebrew University, Rehovoth, Israel, indicated that feeding acidulated soybean soapstock increased the liver storage of vitamin A in chicks. This was not due to improved utilization of performed vitamin A, but to the presence of a carotenoid having pro-vitamin A properties. The pigment was characterized by a single absorption maximum of 460 m μ and has a biological activity of approximately 0.4 I.U. per microgram. It has been shown that lutein is the major precursor of the pigment which is formed by treating lutein, or lutein containing materials with strong acids. The pigment has been tentatively identified as 3-hydroxy -3, 4-dehydro-beta-carotene, which is known to be formed from lutein by the loss of one mole of water.

Investigation of the influence of thiouracil and thyroxine on carotene and vitamin A utilization indicates that thiouracil does not hinder carotene conversion and that thyroxine definitely enhances the utilization of dietary vitamin A. (A10-AH-7)

C. Nutritive Value of Feeds.

1. Effect of feeding cottonseed meal. In continuation of cottonseed meal studies at Glendale, in cooperation with the University of Arizona, seven samples (representing glanded and glandless meals prepared by different processes) were tested for their effect on coloration of stored eggs. There were some discolored yolk in some of the eggs stored 15 days when several of the five glanded meals were fed, and after six months' storage, practically all the yolks of eggs produced from feeding these five meals were discolored. One of the glandless meals caused discolored yolks after six months' storage; whereas, the other glandless meal had no effect on the yolks. Since pink whites were present in eggs resulting from feeding four of the five hexane extracted meals, it is apparent that hexane does not remove all components that cause pink whites. (AH e2-17)

2. Nutritive value of grains. Tests to determine the feeding value of corn, wheat, oats, and barley were conducted with laying hens, using protein levels of 10, 12.5, and 15 percent. The diets were isocaloric for each protein level, and only one grain was used as a carbohydrate source per protein level. The results indicate that all of the grains supported egg production at approximately the same level on the 12.5 and 15 percent protein diets. On the 10 percent protein diet, oats gave 60 percent production, as compared with about 44 percent with the other three grains. (AH e2-14)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Nutritive Requirements

- Lillie, R. J., Twining, P. F., and Denton, C. A. 1964. Calcium and phosphorus requirements of broilers as influenced by energy, sex and strain. Poultry Sci. (In press) (AH e2-18)
- Twining, P. F., Lillie, R. J., Robel, E. J., and Denton, C. A. 1964. Calcium and phosphorus requirements of broiler chickens. Poultry Sci. (In press) (AH e2-18)

Digestion and Metabolism

- Menge, H., Miller, E. C., and Denton, C. A. 1964. Effect of a fat-free maternal diet on the fatty acid composition of the progeny. Poultry Sci. 43: 164-168. (AH e2-13)
- Menge, H., Calvert, C. C., and Denton, C. A. 1964. Further studies on the effect of a low-fat diet on reproduction in the hen. Poultry Sci. (Abstract). (AH e2-13)

Nutritive Value of Feeds

- Heywang, B. W., Kemmerer, A. R., and Lowe, R. W. 1963. Discoloration in eggs when cottonseed meal feeding was stopped before the pullets laid. Poultry Sci. 42: 995-997. (AH e2-17)
- Kemmerer, A. R., Heywang, B. W., Vavich, M. G., and Phelps, R. A. 1963. Further studies of the effect of cottonseed oil on discoloration of cold storage eggs. Poultry Sci. 42: 893-895. (AH e2-17)
- Heywang, B. W., Reid, B. L., and Kemmerer, A. R. 1964. Effect of sodium ascorbate on egg shell thickness during hot weather. Poultry Sci. 43: 625-629. (AH e2-15)

AREA NO. 11: POULTRY - IMPROVEMENT OF VIABILITY

Problem. Leukosis continues to head the list of diseases that cause a high mortality among chickens. It is prevalent in both young and mature stocks, and on most, if not all, farms where chickens are reared. It is also responsible for high rates of condemnation at packing plants and poor performance with respect to growth and egg production.

The yearly financial losses to the poultry industry of the United States from leukosis mortality alone are estimated to be in excess of \$65,000,000. At this time when the margin between the cost of production and the price received for poultry products has been reduced to a very low figure, it is more urgent than heretofore that additional emphasis be placed on research directed towards the development of effective control measures for the leukosis complex.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by virologists, pathologists, and a geneticist on basic and applied studies of the neoplasms of the avian leukosis complex. Most of the studies are conducted at the Regional Poultry Research Laboratory, East Lansing, Michigan. Work is also done in cooperation with more than 15 other Federal, State, or commercial agencies located in several sections of the United States.

The primary objective of these studies is to develop a practical program for the prevention of losses due to the diseases of the avian leukosis complex. Most of the effort has been and currently is directed towards two approaches. The first is to develop a program to increase resistance of the chickens to avian leukosis. It has been found that the level of viral stimulated antibodies and certain yet undefined physiologic mechanisms are genetically controlled and have very important influences on resistance. For significant progress in this approach, it has become evident that basic studies must continue to be conducted on (1) mode of inheritance, (2) mechanism of gene expression, (3) interrelationships of resistance to different tumor viruses, avenues of exposure, and other genetically controlled traits, (4) dynamic interrelationship between infection, antibody, and neoplasms, (5) ultrastructure, biochemistry, and the dynamic molecular biology of the causative virus and infected cells, and (6) the mechanism of influence of the bursa of Fabricius on neoplasia.

The second approach is directed towards the prevention of infection and/or elimination of the disease. Avian leukosis is a contagious disease. The infectious virus is transmitted not only by direct contact with infected chickens and with infected environment, but also via the infected embryo-nating egg. The most important prerequisite for progress in the development of eradication measures is a simple but adequate method of detecting

current or past infection. Only recently has notable progress been made on this aspect and further simplification of procedures can be expected. Such fundamental epizootiological information as the extent and prevalence of infection, the modes of spread of infection, the importance of various vectors and reservoirs, the importance of various environmental factors and other concomitant diseases, and the influence of passive as well as active immunity must be obtained before a rational program of eradication can be developed.

Recent developments have demonstrated that there are at least two different families of viruses--not one, as formerly thought--that cause similar types of leukosis. This emphasizes the magnitude of the problem that still faces us.

A cooperative project entitled "Studies on the epizootiology of avian lymphomatosis and related neoplasms" calls for the active cooperation of (1) National Cancer Institute, NIH; (2) the Animal Disease Eradication Division, ARS; and (3) the American Poultry and Hatchery Federation. Also cooperating in this project are poultry industry representatives located in Michigan and Indiana. Furthermore, cooperative projects are in effect with the Alabama and New Jersey Experiment Stations; the Pennsylvania Department of Agriculture; and the School of Medicine, University of Minnesota. The Southern and North Central Poultry Breeding Projects and poultry breeding farms in California and Connecticut are also cooperating in research with the Regional Poultry Research Laboratory at East Lansing. A research contract at the Wisconsin Agricultural Experiment Station has been completed and the final report will be available for the next report.

The Federal scientific effort devoted to the research in this area totaled 11.9 professional man-years. Of this number, 3.0 are devoted to studies of causative agent, 2.0 to epidemiology, 1.3 to improvement through genetics, 1.5 to immunology and vaccination, 2.0 to virus propagation and tissue culture, 0.7 to management practices and 1.4 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The genetic mechanisms of resistance and susceptibility to disease are being investigated. This research is concerned with the relationship of blood group antigens to inheritance of disease resistance and the mode of gene action controlling resistance to viruses of the avian leukosis complex. Research is being continued on selective breeding practices as a means of controlling poultry diseases.

Studies are being made on changes in physical characteristics of chicken blood that may be related to susceptibility to respiratory disease viruses. The extent to which hormones of the various endocrine glands affect resistance to disease is being investigated. Consideration is also given to the relationship of nutrition to disease resistance. Metabolic studies are being conducted to determine those nutrients that affect resistance

of chicks to viral infections.

The total State scientific effort devoted to Improvement of Viability in poultry is 1.1 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Studies of the Causative Agent.

Studies of viral strains causing primarily neurolymphomatosis have continued. Transmission with the JM strain can easily be effected in line 7 chickens by inoculation with cell suspensions and direct contact with infected birds, but disease induction with cell-free filtrates has been disappointing. Other sources of virus such as the B14 strain of Houghton, England, the Hiawassee field isolate, and the line 7 RPL isolate have given similar results. Problems which must be resolved before critical results can be obtained with this type of virus include (1) the development of a flock of line 7 chickens free of this type of virus infection, (2) provide the type of high security facilities capable of containing the more contagious neural disease virus, and (3) develop better standards for quantitating inoculation response since gross or even microscopic examination does not identify all diseased birds.

Studies on the oncogenic potential of tumor viruses revealed that a standard preparation of Rous sarcoma virus at high dilution causes visceral lymphomatosis and erythroblastosis. These neoplasms have now been found to be caused by a leukosis virus associated with Rous virus which other workers have shown to act as a helper virus in the production of infectious Rous virus particles.

In two tests, mouse leukemia viruses were inoculated into susceptible line 151 embryos and day-old chicks. In the first test, 19 of 177 chickens developed one or more leukotic neoplasms, but in a more extensive second test where 4 different strains of virus were used, only 2 of 493 chickens showed leukosis lesions. Potent avian leukosis virus (strain RPL 12) also failed to induce disease in leukemia susceptible mice. These experiments provide no evidence that the leukosis viruses are capable of crossing the avian-murine interspecies barrier.

Ablation of the bursa of Fabricius has been found to have a profound effect in reducing the incidence of visceral lymphomatosis in chickens inoculated with strain RPL 12. In contrast, the removal of all thymus tissue had no detectable effect. The removal of either organ had no effect on the occurrence of erythroblastosis, osteopetrosis, or other neoplasms. The marked reduction in occurrence of visceral lymphomatosis in bursectomized birds was obtained even though time of inoculation varied from 1 to 28 days at bursectomy from 1 to 56 days of age. (AH e6-10)

Since the RIF test for the detection of leukosis virus is dependent on the transformation of chick embryo cell cultures by the Rous sarcoma virus, it was important to determine the cause of resistance to transformation found in embryos of some of the isolated line 15I population. Several attempts to detect or isolate a resistance inducing virus have failed. In addition, 121 hens of 2 generations of this population did not have antibody to a leukosis virus.

In the testing of embryos from individual sire-dam matings by both the tissue culture and chorio-allantoic membrane methods, it was determined that the lack of sensitivity in line 15I embryos was genetic and probably due to the single recessive gene, rs. Other studies showed that this type of resistance is present in other stocks of chickens and should be taken into consideration when conducting RIF tests directly on embryo cell cultures. (AH e6-3 and AH e6-24)

In collaborative studies with Drs. Ziegel and Rauscher of the National Cancer Institute, it was found that the virus which occurs naturally in the pancreas of many embryos and young chicks is in fact a visceral lymphomatosis virus. Pancreatic extracts compare well with strain RPL 12 with respect to induction of leukosis and causing a high rate of infection of embryos and chicks resulting in virus multiplication in the acinar pancreatic tissue.

Studies in cooperation with Dr. Levine of American Cyanamid Co. provide strong evidence that the resistance inducing virus from their flock of chickens is in fact leukosis virus. Virus isolated from embryos of two different sources was propagated through 11 and 12 serial tissue culture passages. The last passage supernatant was inoculated into line 15I chickens and a high incidence of neoplasms of the avian leukosis complex (ALC) resulted. (AH e6-24)

B. Immunology and Vaccination.

Six additional experiments on attempts to develop an effective killed vaccine have been completed. It was found that 0.4% formalin for 5 days or 0.5% betaprone for 2 days inactivated all the virus in a 10% tumor extract stored at 2°C and maintained at a pH of 7.0-7.4. With storage for 17 days, 0.2% formalin was sufficient to result in complete inactivation. Treatment with ethyl ether and tween caused complete inactivation, but no immune response was obtained even when Freund's complete adjuvant was used.

Using preparations of strains RPL 12 or RPL 29 virus treated as above, it has been found that good neutralizing antibody levels were obtained only when sufficient live virus was present in the vaccine to cause deaths from leukosis. When live virus was absent, the vaccinated chickens did not develop antibody during an eight-month period even though good adjuvants were given with the vaccine. This failure may be due to an insufficient amount of inactivated viral antigen injected even though the infectivity

titer of the source material was quite high.

Results on the study of the antigenic character of ALC viruses indicate that many of them can be used as a "helper" virus with defective Rous sarcoma virus (RSV) in producing fully infective viruses having the antigenic character of the "helper" virus. Seven specific helper - RSV strains have been produced. These include three "laboratory" strains, RPL 12, RAV-Rubin, and strain A, and four recently isolated field strains. These new RSV strains produce typical focal areas of altered cells in cultures of chick embryo fibroblasts. Potency determinations have been made and antigenic character studies are now in progress. Preliminary results indicate that antigenic analyses of field isolates and/or serum analyses from field outbreaks can be made and relationships determined between viruses causing these outbreaks and the standard stock strains.

Studies on the complement fixation test for avian leukosis (COFAL) viruses indicate that it is comparable in sensitivity and specificity to the RIF test. Of 187 comparable tests conducted, an agreement of 98% has been obtained. Also, there is an indication that the COFAL test may be adapted to detect tumor viruses which do not show RIF activity.

The COFAL test is shorter, simpler, and less expensive than the RIF test. Sufficient high titer complement fixing hamster anti-Schmidt-Ruppin RSV serum has been produced to do approximately 50,000 COFAL tests.

Studies on the relationship of virus dose, age of host, route of inoculation and neoplastic response to the immune response are in progress. The results demonstrate important interrelationships. Doses which induce a neoplastic response also induce an immune response, and conversely in dose lots which do not produce neoplasms, the incidence of the immune response is very low or absent. (AH e6-17)

C. Epidemiology.

In the 1952-53 Pennsylvania Random Sample Test, mortality due to avian leukosis complex (ALC) varied among entries from 0 to 21%. This is an indication of variation in susceptibility and/or variation in congenital and acquired infection. Even though there was considerable mortality before and after the birds were 5 months of age, there was no correlation among the entries between early and late ALC mortality. No correlation was found between the presence of maternal antibody, nor acquired antibody measured at 338 days, and the incidence of neoplasia. By 338 days in the 1962-63 test and 150 days in the 1963-64 test, all entries tested were almost 100% Rous sarcoma virus antibody (RSVA) positive. The rate of mortality in the 1963-64 test has been very low.

A cooperative study with the New Jersey Agricultural Experiment Station has demonstrated the importance of contact transmission and rearing on recently used litter on the incidence of ALC. Isolated 151 chickens on clean litter

had a lower mortality than those in contact with commercial chickens or those reared on dirty litter. The commercial chickens reared on contaminated litter had the highest ALC mortality.

In a cooperative study with the National Institutes of Health and Klager Hatcheries, over 1500 blood samples from chickens of 13 flocks in Southern Michigan were tested. The percent with maternal RSVA varied from 30 to 93%. There was a great variation within the same flock on different samplings taken at monthly intervals. March had the lowest mean incidence of RSVA positives of 56.3%, and February the highest of 78.7%. There is an overall repeatability of 80 to 92% (depending on criteria used) with the RSVA test and a positive correlation of 0.8 between the RIFA and RSVA tests. Thus the simpler and more rapid RSVA tests is sufficiently accurate for epizootiologic studies. Ninety-nine mammalian sera have been tested for RSVA. Five human sera have shown low anti-RSV activity and 2 have shown high activity. Both the latter came from patients with acute juvenile stem cell leukemia. None of 30 bovine and canine sera showed activity. (AH e6-27)

D. Improvement through Genetics.

Through the use of artificial insemination and individual cages, the number of individual male matings for each inbred line has been increased. The second generation of full-sib matings under this system has resulted in information on reproductive performance indicating that selection among full-sib mated families may result in fairly reproductive inbred lines. The progress of inbreeding is being followed with continued skin grafting and blood typing work in cooperation with the Alabama Experiment Station. (AH e6-2, AH e6-28)

The existence of a single autosomal dominant gene (Rs) which influences in vitro as well as in vivo susceptibility to Rous sarcoma virus (Bryan strain) has been fully confirmed. Preliminary studies suggest that the homozygous resistant (rs rs) animals or cells do not support virus growth as well as susceptible (Rs rs; Rs RS) ones. (AH e6-24, AH e6-29)

Efforts to evaluate the usefulness of inoculation with tumor virus preparation as a method of selection for resistance to lymphomatosis indicate that at least some virus isolates rank a series of matings of different inbred lines differently than others. This and other evidence suggests that resistance to avian tumor viruses is specific to the particular virus isolate used, rather than general resistance to all the viruses of the avian leukosis complex. These studies have been extended to include four field locations where the same series of matings are exposed naturally in all locations and inoculated at the Regional Poultry Research Laboratory. (AH e6-29)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Studies of the Causative Agent

- Burmester, B. R. and Fredrickson, T. N. 1964. Transmission of virus from field cases of avian lymphomatosis. I. Isolation of virus in line 151 chickens. J. Nat. Cancer Inst. 32: 37-63 (AH e6-10).
- Dmochowski, L., Grey, C. E., Padgett, F., Langford, P. L., and Burmester, B. R. 1964. Submicroscopic morphology of avian neoplasms. VI. Comparative studies on Rous sarcoma, visceral lymphomatosis, erythroblastosis, myeloblastosis, and nephroblastoma. Texas Reports on Bio. Med. 22: 20-60 (AH e6-24)
- Peterson, R. D. A., Burmester, B. R., Fredrickson, T. N., Good, R. A. 1963. Prevention of lymphatic leukemia in the chicken by the surgical removal of the bursa of Fabricius. J. Lab. Clin. Med. 62: 1000 (AH e6-10)
- Peterson, R. D. A., Burmester, B. R., Fredrickson, T. N., Purchase, H. G., and Good, R. A. 1964. Effect of bursectomy and thymectomy on the development of visceral lymphomatosis in the chicken. J. Nat. Cancer Inst. 32: 1343-1354 (AH e6-10)
- Piraino, F., Okazaki, W., Burmester, B. R., and Fredrickson, T. N. 1963. Bioassay of fowl leukosis virus in chickens by the inoculation of 11-day-old embryos. Virology 21: 396-401 (AH e6-3, AH e6-24)
- Zeigel, R. B., Burmester, B. R., and Rauscher, F. J. 1963. An electron microscopic study of the chick embryo pancreas following natural and artificial transmission of avian tumor viruses. J. Cell. Biol. 19: 76A (Ah e6-24)

Immunology and Vaccination

- Fredrickson, T. N. and Burmester, B. R. 1964. Responses of different stocks of chickens to inoculation as embryos and as chicks with strain RPL 12 and field isolates of leukosis virus. Avian Diseases 8: 123-134 (AH e6-24)
- Purchase, H. G., and Okazaki, W. 1964. Morphology of foci produced by standard preparations of Rous sarcoma virus. J. Nat. Cancer Inst. 32: 579-589 (AH e6-24)

Improvement Through Genetics

- Crittenden, L. B. 1963. A simple method of skin grafting in chickens. Poultry Sci. 42: 1398-1399 (AH e6-28)
- Crittenden, L. B., Johnson, L. W., and Okazaki, W. 1964. Histocompatibility and erythrocyte antigen variability within highly inbred lines of White Leghorns. Transplantation 2: 362-374 (AH e6-28)
- Crittenden, L. B., Okazaki, W., and Reamer, R. 1963. Genetic resistance to Rous sarcoma virus in embryo cell cultures and embryos. Virology 20: 541-544 (AH e6-24, AH e6-29)

AREA NO. 12: POULTRY - BROILER LOSSES

Problem. Effective control of Air Sac Disease to reduce the continuing losses from condemnations is a major problem of the broiler industry. Since the presence or absence of pathogenic strains of the pleuropneumonia-like organism, *Mycoplasma gallisepticum*, largely determines whether chickens will develop Air Sac Disease in the presence of secondary invaders, such as *E. coli*, Newcastle disease or infectious bronchitis, the value of effective methods for control is evident. Additional basic information is needed concerning the behavior of the organisms associated with this disease complex and the host response to them. The great range in host response indicates that genetic variation, nutrition, environment and management play a part in the severity of the response in individual flocks of chickens.

USDA AND COOPERATIVE PROGRAM

A basic and applied program of research directed toward the reduction of losses from broiler condemnations is to be conducted jointly by specialists in agricultural engineering, animal diseases and poultry management, genetics, nutrition, and physiology. Two locations are involved in this work, the Southeast Poultry Research Laboratory, Athens, Georgia, and the South Central Poultry Research Laboratory, State College, Mississippi.

The Animal Husbandry Research Division's work at Athens emphasizes genetics and physiology in relation to the Air Sac Disease complex and the work at State College will emphasize environment and management in relation to condemnation losses.

This research program is cooperative with the Animal Disease and Parasite and Agricultural Engineering Research Divisions, ARS. Local cooperation of State experiment stations and the broiler industry in the southeast and south central regions is an important part of the program, particularly with respect to field trials.

The Federal effort devoted to research in this area totals 3.2 professional man-years. Of this number 1.0 is devoted to management practices, 0.5 to equipment and facilities, 1.0 to genetic control, 0.5 to environmental physiology, and 0.2 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The States are engaged in basic and applied research investigations on the effects of adverse environmental factors on broiler losses. Genetic and physiological aspects of environmental stresses are being investigated. Studies are being made on the effect of such adverse conditions as; sudden chilling, prolonged chilling and overheating prior to or during the

brooding period on rate of mortality, rate of growth and extent of condemnation losses. Consideration is being given to other environmental factors as housing, density, type of housing, air movement, air contamination, litter management and sanitation.

The total State scientific effort devoted to Environment as related to broiler losses is 4.7 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics in Relation to Airsacculitis.

In an effort to control egg transmission of Mycoplasma gallisepticum, hatching eggs from a randombred population were immersed in Tylosin tartrate for 30 minutes at the Southeast Poultry Research Laboratory. The chicks hatched from these eggs were reared in isolation and in several small lots. No reactors to the serum plate test were found up to 13 weeks of age, when the birds were transferred from batteries to floor pens. These birds will be used as a base population in an attempt to produce lines resistant and susceptible to the organisms responsible for airsacculitis.

B. Management in Relation to Condemnations.

Comparisons were made in field trials of zinc baciferm and aureomycin prestarters. There were 138,602 chickens started in three series of trials on seven different farms. The differences between the two prestarters varied with farms. The growth and feed conversion were improved enough by either prestarter to increase the margin over feed cost over that of the untreated controls.

On-the-farm studies of avian nephrosis (Gumboro Disease) in broilers have been conducted. None of the various preventive methods and treatments studied have been consistently effective for avian nephrosis. Treatments included sulfonamides, antibiotics, vitamins and molasses. House treatments included litter removal, new litter, disinfectants, and lye. When used with security management, lye and a synthetic phenolic disinfectant showed some promise. Mortality studies involved 2,060,528 chicks started in 209 houses on 28 infected farms. Field trials included 851,482 chickens started on the 28 farms. (AH e7-1)

At the Southeast Poultry Research Laboratory blood samples were collected from broiler field trials totaling 143,350 birds. These birds consisted of both PPLO-free and non-PPLO-free stock. Limited data indicate that when chicks from PPLO-free and positive parentage were reared together, the condemnation rate was significantly higher among the PPLO-free lots than when this stock was reared separately. Also, it appears that environmental stress during the summer is not sufficient to greatly increase the condemnation rate of PPLO-positive stock.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Management in Relation to Condemnations

- Parkhurst, R. T. 1964. Pattern of mortality in avian nephrosis. Poultry Sci. 43: 788-790. (AH e7-1)
- Parkhurst, R. T. 1964. Avian nephrosis (Gumboro Disease) in U.S.A. broilers: Treatment trials. World's Poultry Sci. Jour. 20:3 208-211. (AH e7-1)
- Parkhurst, R. T. 1964. On-the-farm studies of Gumboro Disease. (In press) (AH e7-1)

AREA NO. 13. SHEEP AND GOATS - BREEDING

Problem. The existence of the sheep industry in this country will depend upon sheep producers being able to effectively and efficiently meet competition from other sources of meat and fiber. To meet this competition the farm sheep producer will need more efficient sheep, sheep which are capable of year-round production of more lambs and wool per ewe, often under adverse environmental conditions and with more resistance to disease and parasites. Range sheepmen need information on genetic methods of improving lamb and wool production. More effective systems of mating, breeding and selection need to be tested. Breeding studies on reproductive efficiency, inheritance of feed efficiency, rate of gain and carcass, as well as wool quality, deserve emphasis.

USDA AND COOPERATIVE PROGRAM

This is a continuing program by geneticists on basic and applied studies of breeding to increase efficiency of production of high quality lamb and wool. Work in progress at Beltsville, Maryland, involves breed comparisons and studies of gains resulting from crossing of breeds. At Dubois, Idaho, systems of mating are compared including development and crossing of inbred lines and selected strains. Also studies on heritability and other genetic parameters of economic traits, as well as studies on improved methods of selection are conducted. At Fort Wingate, New Mexico, and on a private ranch in Utah, selection studies are emphasized. Cooperation is maintained with 16 State experiment stations. Several of the studies contribute to the western, southern and north central regional sheep breeding projects.

The Federal scientific effort devoted to research in this area totals 6.2 professional man-years. Of this number 1.4 are devoted to genetics and interrelation of performance traits, 3.1 to selection and systems of breeding, and 1.7 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

Research in sheep and goat breeding seeks information needed for the most rapid genetic improvement of these species. Genetic investigations with sheep include carcass characteristics, wool production, reproductive capacity, performance and progeny testing, selection methods and criteria, early lambing, breed and breed-cross performance, genotype x environmental interactions, development of superior strains and management. Wide ranges in breeds are included in several of the studies permitting estimation of genetic variation which occurs between breeds to be utilized in crossing programs and in breed selection. Greater reproductive capacity is of primary concern in many of the studies, and efforts are being made to increase multiple births, improve frequency of pregnancy, and eliminate seasonal breeding. Frequently this approach to greater reproductive rate

is from the genetic aspects or combination of genetics with other disciplines such as nutrition, physiology, or management. In several of the Southern States, for example, early season breeding to produce lambs is being approached through genetic improvement, hormonal treatment, and temperature control.

Research is conducted also under three regional projects; S-29, Genetic and Physiological Factors Affecting Reproduction of Sheep in the South; W-61, Development of Selection Criteria for the Genetic Improvement of Carcass Merit in Sheep; and NC-50, Improvement of Lamb Meat Production Through Breeding.

Active USDA cooperation in sheep breeding investigations is limited to a few State stations and representation of the USDA on technical committees of regional projects.

Genetic investigations with Angora goats for mohair production are being conducted at the Texas station. Evaluation of four selection methods is being made, and estimates of heritability of economic traits and interrelations between traits are being developed.

The total research effort on sheep and goat breeding research by the State agricultural experiment stations is 23.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Interactions affecting weanling and yearling traits. Interactions affecting 39 weanling and yearling traits of Rambouillet, Targhee and Columbia ewes and rams were studied. These interactions included all combinations between age of dam, sex, years, type of birth-rearing, band in which raised, and type of mating. Interactions between years and type of birth were significant for 12% of the tests and years and band were significant for 24% of the tests. It was found that only a small percent of the yearling traits were affected by the interaction between mating system and type of birth or age of dam. Only a few significant interactions were found to exist between sex and age of dam and sex and type of birth. Ewe lambs tend to be superior to ram lambs in a poor environment but inferior in a good environment. The traits most often affected by interactions were weanling condition (27% of tests over 11 interactions) yearling width of body score (25% of tests over 6 interactions) and weanling weight (23% of tests over 11 interactions). All other traits were affected in less than 20% of the tests which included all available interactions. (AH 61-6)

2. Heritabilities and correlations in weanling and yearling traits. Heritabilities, phenotypic and genetic correlations were studied among 39 fleece and body traits of weanling and yearling Rambouillet, Targhee and Columbia ewes. Heritabilities between 30% - 70% were obtained for weanling

face cover, index, birth weight, and staple length and for yearling face cover, body type, body condition, staple length, fiber crimp, fiber diameter, clean fleece weight, grease fleece weight, scored body width and height at withers. Only a few estimates were above 70% and a few below 30%. There was no difference in estimates obtained from inbred or noninbred groups. The highest positive genetic correlations were found among the various fleece characteristics, especially those describing fiber fineness and between body traits describing body size. Genetic correlations between fleece and body traits were generally low. Genetic correlations between the same traits as weanling and yearling age showed face cover, body weight and staple length to be high, while those involving thigh grade, belly wool, and average daily gain were very low. Other correlations were generally moderate to low. The most important negative genetic correlations were those between yearling variability of fiber diameter and staple length, clean fleece yield and grease fleece weight, thigh grade and staple length, thigh grade and clean fleece weight, side grade and staple length, side grade and clean fleece weight, and staple length and fiber diameter measured in several areas of the fleece. The above correlations were generally of a magnitude exceeding $-.45$. (AH b1-6)

3. The effect of sire on composition of lamb fat. The effect of sire on the composition of ovine fat was studied on fat samples from 180 lamb carcasses. These lambs originated at the Southwestern Range and Sheep Breeding Laboratory, Ft. Wingate, New Mexico, and fattened at New Mexico State University. The fat analyses were carried out at Colorado State University. The analyses revealed that sires had a significant effect on iodine numbers and melting point. Heritabilities of these two traits were found to be 0.31% and 0.33%, respectively. Sex and type of birth had no effect on fat composition of the lambs. (AH b1-10, 11, 12)

4. Relation of growth rate of lambs to carcass composition. A study was conducted at Fort Reno, Oklahoma, to evaluate the influence of different growth rates of lambs on carcass composition involving sixty crossbred milk fat lambs out of Dorset X Western ewes and Western ewes mated to Dorset, Hampshire, and Suffolk rams. It was found that the earlier maturing, slower gaining white-face lambs were fatter by 3.4%, had 1% less bone, 2.4% less lean, and required 23 more days to reach slaughter weight of 100 lbs. than the blackface lambs. Twin lambs averaged 1.6% more fat, 0.8% less lean and 0.8% less bone than singles. (AH b3-7)

5. Repeatability of lamb growth. Repeatability estimates of birth weight, 70 day weight and rate of gain from 70 to 140 days of age were calculated on 829 lambs from Rambouillet and Rambouillet X Panama-Rambouillet ewes born over a 6-year period at Fort Reno, Oklahoma. Repeatability estimates calculated from data adjusted for measurable environmental factors were found to be $0.37 \pm .03$ and $0.14 \pm .03$, respectively. On unadjusted data these estimates were $0.19 \pm .03$, $0.17 \pm .03$ and $0.11 \pm .03$, respectively. When the 70-day weights and gain from 70 days to 140 days were adjusted for birth weight as well as for sex, type of birth and year, the estimates for these two traits were $0.15 \pm .03$ and $0.11 \pm .03$, respectively. (AH b3-7)

B. Selection and System of Breeding

1. Breed comparisons and crossbreeding. The effect of crossbreeding on total production of the ewe was measured by indexes that consider both pounds of lamb weaned and pounds of wool sheared. The data include five purebred groups of sheep including Hampshire, Shropshire, Southdown, Merino and Targhee and one strain evolved from a Columbia-Southdale cross. The work also includes 9 groups of 2-breed cross lambs, 20 groups of 3-breed cross lambs, and 6 groups of 4-breed cross lambs. A total of 2369 lambs over a period of 11 years were included in the study. Three indexes were used. Index I was computed by adding weaning weight of the lamb adjusted for sex and age to the fleece weight multiplied by 2.5. Index II was computed by dividing Index I by the fall body weight of the ewe. Index III was the same as Index I except the lamb weights were not adjusted for sex and age. Production Index I ranked Targhees first (101.1) followed by Hampshires (73.4), Columbia-Southdale (68.9), Merino (62.3), Shropshire (54.7) and Southdown (43.6). When Index II was used the large ewes are penalized and the variation between breeds is reduced. For Index II the Targhees are first (73.0), followed by Merino (62.8), Columbia-Southdale (59.6), Hampshire (59.1), Shropshire (49.9) and Southdown (46.5). The Targhees and Columbia-Southdale ewes were not used in the crossbreeding work. However, when Hampshire, Shropshire and Merino ewes were mated to produce crossbred lambs the indexes were generally superior to purebred ewes producing purebred lambs. When production was measured with Index I and III, Hampshire ewes mated to either Shropshire or Southdown rams produced the highest indexes. When Index II was used, the Merino ewes mated to the mutton breed rams were most productive. For Index I the overall averages for all pure breeds, 2-breed crosses, 3-breed crosses and 4-breed crosses were 58.5, 65.6, 77.9 and 80.2, respectively. For Index II these averages were 54.6, 62.3, 68.3 and 67.4. (AH bl-1, 2, 3, 4)

2. New strains of sheep for lamb and wool production. Work has been started at Beltsville, Maryland, to develop a strain of sheep capable of lambing more than once each year. Such a strain would demonstrate the effectiveness of selection in changing reproductive frequency and removing the seasonal restrictions on reproduction. At present, ewes of this strain are bred to lamb three times in two years. A total of 216 ewes have lambed since 1961. These 216 ewes represent 8 complete reproductive cycles and 201 lambs have been weaned. Fertility is lowest from breeding in April and August and lamb mortality is highest in lambs born in September. Sires used in this strain are selected on the basis of their mothers' fertility and fecundity. (AH bl-17)

3. Comparisons of breeding systems. Preliminary results, based on weanling progeny from 60 Rambouillet sires randomly selected from the upper and lower halves of each breeding group and tested on an unrelated tester stock (8 test ewes per sire), show that test progeny from sires from the noninbred selected control group were superior in both weaning weight and overall merit to those of sires from the randomly bred stabilized control

group, recurrently selected inbred lines, all inbred lines and a few sires from commercial sources. The superiority of the selected control sires was due chiefly to the more open faces, less wrinkled necks, and slightly greater weaning weights of their progeny. The range in overall merit of progeny from the above breeding systems was 15 index points from the best to the poorest, and the range in weaning weights was 4 pounds. The breeding systems ranked, for overall merit, in the order listed above, but for weaning weight the recurrently selected inbred sires ranked last instead of third.

Evaluations of the breeding systems based upon offspring, produced entirely within the system rather than from a tester stock, revealed that the earlier established pattern of selected control superiority and inbred line inferiority continues to be repeated in all breeds at the Dubois station. However, in the Rambouillets, where line cross information is now available on all lines, the line cross progeny were superior to progeny from all other systems in weaning weight and superior to both inbred line and stabilized control progeny in overall merit. Again the superiority of the selected control in overall merit was due principally to less covered faces and less wrinkled necks of progeny from this group. All line cross and inbred line data were adjusted for the effects of inbreeding of the dams in making the above comparisons. These line cross results in the Rambouillets tend to support last year's line cross findings in Columbias and Targhees all of which tend to modify earlier line cross findings based on much less comprehensive data, which generally placed the line crosses in an intermediate position. (AH bl-5).

4. Testing of inbred lines. The testing of inbred lines has been continued with both topcross and line cross matings. For the 27 inbred Rambouillet lines, the topcross offspring were obtained by mating sires from each line to noninbred and unrelated test ewes. Weanling lamb indexes ranged from 134.5 to 145.5 for the top 9 lines with an average of 138.0 for all 27 lines. The top 9 lines from the line-crosses ranged from 146.6 to 157.1 with an average of 142.9 for all 27 lines. Weaning weights of top cross lambs ranged from 73.5 to 77.0 pounds compared to 75.8 to 79.2 for average of the line cross lambs. Only low correlations existed between the ranking of the lines in the test groups for overall merit and weaning weight. Results based upon the overall merit (index) of Targhee topcross progeny as yearlings showed the top third (7) lines to range from 133.3 to 136.0 with an average for all 21 lines of 130.6. Line cross progeny of the top 7 lines ranged from 141.7 to 146.8 with an average of 141.3 for all lines. The yearling progeny indexes for the top third (4) lines in the Columbia breed ranged from 227.9 to 243.2 with an average of 224.5 for all lines for the topcross matings. The top 4 lines in the line cross progeny ranged from 239.8 to 242.4 and averaged 237.4 for all lines. Several of the Targhee and Columbia lines were superior in both the topcross matings and the line cross matings, thus it appears that the superiority of a few lines may be emerging in these two breeds. (AH bl-5 and AH bl-14)

5. Selection for range sheep improvement. To investigate the rate of improvement of wool and lamb production in a commercial flock a cooperative study with the Redd Ranches, LaSal, Utah, and the Utah and Colorado Experiment Stations was begun in 1957 when about 1000 select ewes were chosen from some 15,000 as a select flock from which to raise replacement rams. Since the first lambs were weaned from this flock in 1958, about 1/2 of the ram lambs have been saved and at yearling age 10-15% are used with the select ewes. About 70% are used with the main ewe flock. Selection differentials have ranged from 10-12 lbs. for weaning wt., .09 to .14 inches for staple length and 0.12 to 0.24 for face covering score. At yearling age staple length in these rams has increased an average of .15 inches each year since 1960. Grease fleece weights have varied from 8.68 lbs. in 1960 to 11.30 lbs. in 1962. Body weights at yearling age have varied from 119 lbs. in 1960 to 140 lbs. in 1961. (AH b1-16)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Genetics and Interrelations of Performance Traits

- Harrington, R. B. and Whiteman, J. V. 1963. Estimates of the repeatability of lamb growth as a characteristic of the ewe. J. Anim. Sci. 22(3), p. 819 (abstract). (AH b3-7)
- Marchello, J. A., Cramer, D. A. and Knapp, B. W. 1963. Composition of ovine fat. III. Effect of sire. J. Anim. Sci. 22(3), p. 828 (abstract). (AH b1-10, 11, 12)
- Munson, A. W., Walter, L. E. and Whiteman, J. V. 1964. Relationship of some growth factors with carcass composition in milk fat wether lambs. Oklahoma Livestock Feeder's Day Progress Report, April 18, 1964, pp. 51-57. (AH b3-7)
- Price, D. A., Ercanbrack, S. K., and Wilson, L. O. 1964. Relative accuracies of several methods of estimating clean fleece weight. J. Anim. Sci. 23(2), p. 350. (AH b1-6)
- Wilson, L. O. Lamb Birthcoat. National Wool Grower 54:12. (AH b1-6)

Selection and Systems of Breeding

- Ercanbrack, S. K., Blackmore, D. W., Van Horn, J. L., Blackwell, R. L., Hoversland, A. S., Kyle, W. H., Drummond, J., Terrill, C. E., and Willson, F. S. 1963. Components of variation and covariation of weanling traits of topcross lambs. J. Anim. Sci. 22(3), p. 818 (abstract). (AH b1-14)
- Sidwell, G. M., Everson, D. O. and Terrill, C. E. 1964. Lamb weights in some pure breeds and crosses. J. Anim. Sci. 22(3), p. 822 (abstract); 23(1), pp. 105-110. (AH b1-1, 2, 3, 4)

AREA NO. 14. SHEEP AND GOATS - PHYSIOLOGY

Problem. Inefficient growth and reproductive failures are costly to sheep producers and cause large reductions in efficiency of production. Additional information is needed on the causes of reproductive failures in the female and low fertility or sterility in the male. Also, more information is needed regarding the basic physiological processes involved in growth and reproduction. The normal physiology of all phases of growth and reproduction must be more thoroughly defined along with the effects of important genetic and environmental factors such as breed, age, season, and level of nutrition in order to develop more effective ways of increasing efficiency. Basic information is also needed concerning the development and growth of fiber follicles in order that further improved practices can be developed for wool and mohair production. This research requires studies on the nature and sequence of histological, cytological, and physiological processes involved in fiber follicle initiation and development.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by physiologists and histologists on basic and applied studies of the physiology of reproduction, growth, and development of sheep and goats, including processes involved in fiber and development of sheep and goats, including processes involved in fiber follicle initiation and development. Factors influencing mating behavior, estrus, ovulation, and embryonic development in ewes and mating behavior and fertility of rams are directed toward a more complete understanding of the reproductive processes in sheep. The work is in progress at Beltsville, Maryland; Dubois, Idaho; and cooperatively with Idaho and Oklahoma State Agricultural Experiment Stations. Environmental factors affecting growth and development are being studied in cooperation with five State experiment stations. One study contributes to the Western regional project W-46 on the effects of environmental stresses on range cattle and sheep production. Studies on fiber and follicle development of sheep and goats are in progress at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 2.6 professional man-years. Of this number 0.8 are devoted to physiology of reproduction, 0.1 to environmental physiology, 1.3 to physiology of wool and fiber, and 0.4 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The current research program at the State experiment stations in the area of sheep physiology is concerned primarily with attempts to understand the endocrine shifts responsible for the seasonal breeding behavior of sheep and means of altering it. States in the southern region and the USDA are cooperating in regional project S-29, Genetic and Physiological Factors Affecting Reproduction of Sheep in the South, in a study of the various factors important in seasonal and non-seasonal reproduction. Light, temperature and genetic constitution are receiving major emphasis. Other studies are concerned with determination of abnormalities in the ova which appear to render them incapable of implantation, and nutrition and management factors important in regular reproduction. The technique of ova transplantation has been successfully used in this research.

In an attempt to more accurately assess the effects of stresses of nutrient restriction, altitude and temperature on growth and productivity of range sheep, the States of the western region and the USDA are cooperating in regional project W-46, The Effects of Environmental Stresses on Beef Cattle and Sheep Production. The stations are comparing full feed and water with varying percentage restrictions along with the influence of altitude, physical nature of the diet, range supplementation, geographical location and temperature as these affect blood chemistry, body composition, wool quality, lamb production, and milk production during the nursing period.

The influence of growth rates of ewe lambs on subsequent production is being studied as is the effect of hormones and hormone-like substances, alone or in combination with antibiotics, on growth and fattening of lambs. A fundamental approach to gain an understanding of the physiology of growth involves a study of the effect of feeding specific metabolites such as sodium propionate upon blood glucose levels and growth rates of lambs.

The total State scientific effort devoted to sheep and goat physiology research is 10.3 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Breeding capacity of range rams. The number of ewes with synchronized estrus periods which can be successfully mated to one ram was investigated. Ewes were checked for estrus and placed with the ram at 8-hour intervals. Most of the 59 to 62 ewes assigned to each ram were in heat within a 4-day period (equivalent to 250 ewes in normal mating.) Sixty-six percent of the synchronized ewes lambed from the first exposure which excelled fertility of control pens. Thus, the number of synchronized ewes which can be bred naturally is much higher than expected. (AH 61-7)

2. Synchronization of estrus with orally active progestin. A 2-year study showed good synchronization with all treatments with 85% of all ewes coming into heat within a 4-day period. Fertility was higher at the second post-treatment estrus (79%) than at the first (59%). Feeding progestin for 12 or 14 days had no significant effect on subsequent fertility but 60 mg. daily dosage gave better fertility than 50 mg. (74% vs. 64%, $P > .05$). (AH b1-7)

At Fort Reno, Oklahoma, estrus was effectively synchronized in 3 of 4 trials with non-lactating ewes. Lactating ewes did not mate immediately after feeding progestin but did show synchronized estrus periods about 3 weeks after end of feeding. Milk production was unaffected. Estrus was not well synchronized in late summer breeding of 10-month old ewe lambs when mated at second estrus after end of breeding. (AH b3-7)

3. Effects of variation in light on reproductive phenomena during the breeding season. Mature ewes were randomized (1961-63) within breed and age into 8 groups receiving normal light, continuous light, continuous darkness and combinations changing after 17 and 34 days, and intermittent light (2 hrs. on and off). Treatment began at about the first and ewes were mated at the third synchronized estrus. Corpora lutea and ova or embryo data were obtained at 3 and 31 days post breeding. Light treatment had a significant effect on ovulation rate ($P < .02$, range 1.73-2.17). Continuous dark and intermittent light had the highest rates. There were no significant differences in rate of ova recovery, fertilization, abnormal ova, abnormal embryos or normal embryos at 31 days (ave. 1.45/ewe) or in apparent loss of potential embryos. (AH b1-7)

4. Ovarian response to PMS in progesterone and estradiol treated ewes. Percent of ewes ovulating were control, 100; 8 mg. progesterone daily plus PMS, 80; 16 mg. progesterone daily plus estradiol plus PMS, 80; 1200 i.u. PMS on day 14, 78; 8 mg. progesterone daily, 20; 16 mg. progesterone daily plus PMS, 10; 16 mg. progesterone plus estradiol, 10; and 16 mg. progesterone daily, 0.

Average follicular fluid weights were significantly higher in groups receiving 8 and 16 mg. progesterone plus PMS and tended to be lower in groups receiving 16 mg. progesterone only or 16 mg. progesterone plus estradiol. Average uterine weight was significantly higher in the group receiving PMS only (91.3 gm.) and significantly lower in groups receiving 8 and 16 mg. progesterone only (53.4 and 44.1 gm.). The results indicate a gonadal-gonadotropic hormone interaction probably at the level of the ovaries. (AH b1-7)

5. Vaccination for enzootic virus abortion in sheep. Approximately 400 yearling and 400 2-year old ewes were vaccinated with a killed viral vaccine in the fall of 1960. More of the vaccinated ewes had live lambs and fewer had dead lambs than non-vaccinated ewes but the differences were not significant. However, the number of dry ewes including ewes with unobserved abortions, was significantly greater (158 of 833 ewe records) for non-vaccinated ewes than for the vaccinated ewes (20 of 669 ewe records). (AH b1-7)

6. Fetal electrocardiography in livestock. Extensive studies on fetal electrocardiography of cattle, sheep and goats at Beltsville, Maryland, show it to be a useful technique in detecting pregnancy and fetal well-being. Tracings can be obtained in five minutes or less with cattle. Fetal R waves can be detected by at least mid-term and with an accuracy of 100% during the last 3 months of gestation. The fetal heart rate tends to decline and the amplitude of the fetal R wave increases with fetal age. Pregnancy was detected in all 11 cases with dairy goats and as early as mid-term. A different technique is needed for sheep because of the electrical insulation properties of wool and high noise factors. Silver plated probes inserted subcutaneously offer promise. About 90% accuracy has been obtained in detecting pregnancy in ewes. Vaginal and rectal electrodes are being developed. (AH b2-12)

B. Environmental Physiology

1. Effect of geographic location on color of wool. Comparisons of color were made from individual fleece tops from comparable groups of Rambouillet rams kept in Maryland, Georgia, Idaho, and New Mexico over a four-year period. Rams kept outside showed slightly more color than rams kept indoors. Individual and yearly variations in color were found. In general, fleeces produced in the dry areas of Idaho and New Mexico were white or nearly white, while those produced in the more humid areas of Georgia and Maryland, tended to be yellowish in color. (AH b2-8)

C. Physiology of Wool and Fiber

1. Comparison of a normal and bare skin area in a lamb. Biopsies of normal and bare areas of skin of a 7-month old Columbia X Southdale lamb showed that the keratinized epidermis of the bare area was thicker than the epidermis of the woolled skin. The general blood supply of the bare skin appeared normal but it lacked the branches of arterioles and capillaries supplying wool follicles. Thus, it appears that additional branching of blood vessels in woolled skin is conditioned by the density and type of the follicular population. (AH b5-1)

2. Lipid content and incidence of cholesterol in sebaceous glands of sheep and goats. Tests for lipid content and incidence of cholesterol in sebaceous glands of Merino, Dorset, Shropshire, Morlam, and Navajo skin biopsies show that seasonal differences may exist for incidence of cholesterol but not for lipids for both rams and ewes. (AH b5-1)

3. Incidence of lecithin in the skin and follicles of sheep and goats. Lecithin could not be demonstrated in secreting sebaceous glands of postnatal sheep and goats but it was present in fetal glands. No traces of lecithin were found histochemically in or about growing wool, mohair, or hair follicles but it was invariably present in non-growing or shedding fibers of goats. (AH b5-1)

4. Observations on mohair follicles and lock types. Skin biopsies from 11 Angora goats in Texas and 9 in South Africa revealed that fibers from secondary follicles were generally not medullated except one with straight mohair locks. Medullated fibers were lowest with ringlet locks while intermediate for mixed or flat type locks. Medullated fibers, generally from central primary follicles, made up about 3.5% or less of the total fibers. (AH b5-5)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

- Hulet, C. V., Foote, W. C., and Blackwell, R. L. 1964 Effects of natural and electrical ejaculation on predicting fertility in the ram
J. Anim. Sci. 23(2): 418-424. (AH b1-7)
- Hulet, C. V. and Foote, W. C. 1964. Effects of variation in light on reproductive phenomena in ewes during the breeding season. J. Anim. Sci. 23(3): p. 861 Abstract. (AH b1-7)
- Foote, W. C. and Hulet, C. V. 1964. Ovarian response to PMS in progesterone and estradiol treated ewes. Proceedings Western Section Amer. Soc. Anim. Sci. 15: XVI-1 through 6. Also J. Anim. Sci. 23(2): 591. Abstract. (AH b1-7)

Physiology of Wool and Fiber

- Margolena, L. A. 1963. Sebaceous glands of sheep and goats. The Virginia Journal of Science. Proc. vol. 14(4): 170. Abstract. (AH b5-1)
- Margolena, L. A. 1963. Comparative study of a normal and a bare skin area in a Columbia X Southdale lamb. Zeitschr. mikr.-anat. Forschung, vol. 70, Heft 4, 478-483. (AH b5-1)

AREA NO. 15. SHEEP AND GOATS - NUTRITION AND MANAGEMENT

Problem. The cost of feed is the largest single expense in the production of lamb meat and wool. Information that would increase the efficiency of feed utilization, reduce feed costs and increase productivity through better feeding practices would help the sheep producer meet the cost-price squeeze. Such information will come from basic studies of the development and function of the rumen, together with an understanding of how nutrients are metabolized in the animal. Such an understanding will enable sheep producers to modify and supplement rations in ways that will result in maximum production of desirable meat and wool. Much of the success or failure of sheep enterprises depends on production practices. Producers need better methods of animal management for the reduction of lamb mortality and disease and parasite losses, also procedures for handling ewes during breeding, gestation and lactation, as well as other labor-saving procedures and devices for the routine handling of sheep.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen, involving basic nutrition and ruminant physiology studies, as well as application of known and new principles, in the development of better and more economic feeding practices of farm and range sheep. Basic studies on physiology and feeding practices and known and new principles in a number of fields are applied to the development of more productive management practices for farm and range sheep. These programs are carried on at Beltsville, Maryland; Dubois, Idaho; and College Station, Texas, in cooperation with other Divisions of ARS, and in formal and informal cooperation with State Agricultural Experiment Stations of Delaware, Idaho, Maryland, Montana, Oklahoma, Texas, and Utah.

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years. Of this number, 1.1 are devoted to digestion and metabolism, 0.5 to forage evaluation and utilization, 1.2 to range and pasture management, 0.4 to management practices, equipment and facilities, and 0.4 to program leadership.

A grant involving Public Law 480 funds is in progress at the Ankara University, Ankara, Turkey, and is related to the methods of feeding and management on white muscle disease in lambs. The program is supported for 3 years (1962-1965) by \$9333, equivalent in Turkish lire.

PROGRAM OF STATE EXPERIMENT STATIONS

Basic studies of the function of the rumen, including the function of rumen microorganisms and the metabolism of products produced by rumen microbial activity are being conducted. (Additional investigations of rumen function appear in area #1.) The effect of various mineral, hormonal, or antibiotic supplements upon ration digestibility and animal response are also under study.

Investigations are concerned with increasing the efficiency of sheep production through the use of concentrates at specific times in the growth of lambs (creep feeding), by formulating suitable rations for fattening lambs, and by devising economical rations for maintaining breeding ewes. The use of high-moisture corn and of the increased energy and protein available in the newly developed higher oil and higher protein corn are being studied.

Forage utilization studies include: (1) The influence of trace mineral supplementation. (2) The effect of grazing system upon forage quality and degree of utilization. (3) Forage digestion in the rumen.

The quantitative requirements for and the metabolism and interrelations of various minerals, proteins, and vitamins are being evaluated. The use of hormone, antibiotic, enzyme or other feed additives in improving growth and feed efficiency is a very active area of study. The relation of nutrition to animal disorders such as "stiff lamb disease," nitrate poisoning, and trace mineral deficiencies is receiving attention. The effect of prenatal nutrition upon prenatal and postnatal development of the young is also under study.

Management studies underway include: (1) Early weaning vs. conventional weaning. (2) Creep feeding. (3) Concentrate supplements for wintering ewes. (4) Gleaning corn fields with sheep. (5) The production efficiency of different weights of feeder lambs and of wether sheep for wool and mutton production. (6) Management effects upon rangeland and grazing animals. (7) Scales for chute sorting. (8) Self feeders.

The State Stations have 14.3 professional man years devoted to this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Metabolic disorders. A commercial ground limestone (carbotex), ground oyster shell, and a commercial defluorinated dicalcium phosphate (polyphos) were added to a known calculogenic basal diet of ground sorghum grain (40), cottonseed hulls (40), cottonseed meal (10), and molasses (10) to study their effectiveness in controlling urinary calculi in lambs. Daily feed consumption and average daily gains were 4.6 and 0.45 lb., 4.3 and 0.45, 4.0 and 0.35, and 3.4 and 0.33, respectively. The proportion of animals affected (stones in bladder or clinical cases) was 25, 15, 50, and 65%, respectively.

Ammonium chloride was effective in controlling urinary calculi in a 3-year study involving 91 steers and 220 lambs. Wethers developed more clinical cases while steers had a higher incidence of stones in the bladder. Neither limestone nor disodium phosphate was an effective control measure with steers, while limestone reduced the incidence 50% in wethers and disodium phosphate doubled the incidence. (AH b2-1)

Studies have been conducted at Ankara, Turkey, on white muscle disease of lambs. Two hundred and thirty-four affected lambs were treated by injection with 1 ml. of 0.1% solution of sodium selenite and of these, 128 received a second injection 10 days later. Recovery rate of the affected lambs was 94% and generally a significant improvement was noted within 24 to 48 hours after the first injection. In 1963, 128 affected lambs were injected with 1 ml. of 0.1% solution of sodium selenite in combination with an oral dose of 2 grams of vitamin E. Recovery rate of these lambs was 99%. Treatment with vitamin E alone was not as effective as treatment with sodium selenite. Treatment of pregnant ewes by injection with an 0.1% solution of sodium selenite did not yield conclusive results in preventing white muscle disease in the lambs. Injection of 645 unaffected lambs, in affected flocks, with sodium selenite prevented the occurrence of white muscle disease. Sodium selenite injection did not increase the weight gain of lambs when applied either to pregnant ewes or to their lambs. (A22-AH2- Turkey)

2. Feeding practices and procedures. Mortality of sheep (15 per group) receiving alfalfa hay pellets ad libitum, limited amounts of alfalfa hay pellets, concentrates and chopped hay mixture ad libitum, and limited amounts of concentrate-chopped hay mixture is being studied over their lifetimes. Only one death was ascribed to the treatments in the first year. This occurred in the self-fed pellet group and liver and intestinal pathology were found.

A technique has been developed to study depraved appetites of sheep receiving limited amounts of pellets by measuring the amount of wood consumed. This was inversely correlated with level of feed. Symptoms were reversible and considerable individual variation occurred. Animals showing most depravity of appetite also consumed the most feed when received ad libitum. (AH b2-5)

Metabolic fecal nitrogen excretion of 0.576 and 0.601 grams N per 100 grams of dry matter consumed by sheep on roughage diets adequate in all known nutrients were very similar to those determined by other investigators on low N diets (0.4 to 0.6 g. N/100 g. d. m.) and appeared to be independent of diet digestibility. (AH b2-7)

The effects of physical form, quality of forage and concentrate supplementation were studied factorily on the ad libitum forage consumption by yearling ewes. Differences in forage quality were obtained by diluting alfalfa hay with straw, and cracked corn was used as the concentrate. Results of the first one-half of the experiment indicated that voluntary consumption of pelleted forages was consistently greater than for the same forage, unpelleted and the difference increased with decreasing forage quality. Voluntary intake of pelleted forage was little affected by forage quality. Addition of concentrate had little effect on consumption of pelleted forages but decreased consumption of ground forages by an amount equivalent to the dry matter consumed in form of concentrate. (AH b2-7)

Winter feeding trials on 540 ewes were conducted to find a more economical and time saving method of feeding pregnant ewes. Comparisons were made of 5.8 pounds of baled hay fed on ground, 4.7 pounds of alfalfa hay pellets (100%), and pellets at 95 and 90% of NRC recommendations. Method of feeding and level of feed intake had no effect on body weight gains of ewes during feeding or on birth weights of lambs. Percent and pounds of lambs weaned of ewes lambing were 127 and 98, 123 and 97, 130 and 101, and 128 and 101, respectively. Grease fleece weights were slightly higher for ewes fed pellets vs. baled hay but level of pellet feeding had no effect.

Feeding ewes after lambing for about 25 days before being turned to grass or baled alfalfa hay or self fed on ground alfalfa hay pellets had no effect on pounds of lamb weaned per ewe lambing. In another experiment, lactating ewes self-fed pellets consumed 9.4 lb. and produced lambs gaining 0.4 lb. more in 20 days than ewes hand-fed 6 lb. of pellets per head per day. In another experiment, after lambing, 144 ewes with 170 suckling lambs were fed alfalfa hay, plus 1 lb. of oats; self-fed pellets containing 12.5% oats; alfalfa hay, no grain; and alfalfa pellets, no grain. Average body weights of the lambs at about 30 days of age were 26, 28, 24, and 25 pounds, respectively, showing a slight advantage for pelleting and supplementing with grain.

Ewe lambs which were fed baled alfalfa hay (4.5 lb.) on the ground are being compared with lambs fed 3.4 lb. of alfalfa pellets and lambs receiving pellets ad libitum in self-feeders during their first winter. Average body weights of lambs after winter feeding were 101, 116 and 143 lb. and yearling grease fleece weights were 9.5, 10.3 and 11.2 lb., respectively. Group differences narrowed to 6 and 0.8 and 7 and 0.6 lb., respectively, at 2 and 3 years of age. Lamb production was slightly greater for the self-fed ewes as 2-year olds. Lamb production per ewe as 3-year olds was 93, 92, and 91 lbs., respectively. (AH b3-9)

3. Studies on nutritive requirements of sheep. Over a period of 90 days from mid-April to mid-July the maintenance requirement of 15-month old crossbred wethers was 50 gm. of dry matter (alfalfa hay pellets) per day, per unit of metabolic size (kg. body weight 0.75). (AH b2-7)

Ewes fed 4.5 lb. ground alfalfa hay pellets the last 6 weeks of gestation, according to NRC recommendations, were compared with groups fed at 95, 90 and 85% of recommendations, respectively. Level of intake had some influence on body weight gains during feeding but only a small effect on birth weight. (AH b3-9)

B. Forage Evaluation and Utilization

1. Forage evaluation. Crown vetch in early bloom was cut and frozen and later fed to 10-month old wethers for 26 days. Average energy digestibility was 61% and voluntary consumption was 66 gm. of dry matter, per day, per kg. body weight 0.75. Average refusal was 8.6% of dry matter offered. These values are similar to published values for alfalfa, birdsfoot trefoil, and red clover harvested in early bloom. (AH b2-7)

2. Forage intake by range sheep. Digestion trials were conducted on a tall forb-type high mountain summer range at early, intermediate, and late stages of maturity. Forage was sampled by pre-fasted esophageal fistulated sheep. Crude protein and ether extract in the sheep's diet decreased with forage maturity from 17.0 to 14.1% and 3.7 to 3.3%, respectively. Nitrogen free extract content of the forage increased from 18.3 to 19.4% and lignin content from 9.4 to 11.5%. Gross energy content of the diet decreased from 1953 to 1943 kcal. A significant difference due to stage of maturity was found for all chemical components of the diet except crude fiber. Significant differences due to animal samples were found for crude protein ether extract, and crude fiber. A significant animal by period interaction was found for crude fiber. Dry matter digestibility decreased as the summer progressed. (AH b3-9)

C. Range and Pasture Management

1. Grazing practices. In grazing sheep and cattle together stocking rate, or cattle-sheep ratios, had little, if any, effect on animal gain. Overall average daily gain for sheep was 0.33 lb. There were no significant differences in forage consumption or digestibility between animal treatments and stocking rates. Differences between sheep treated alike were very large. Gains of harnessed bagged sheep were considerably less during sampling period than for untreated lambs. Neither cattle nor sheep hematocrits or sheep fecal egg counts were affected by animal treatments. Thus it appears that differences in animal gains were not related to an interaction between livestock species in helminth parasite relationships. (AH b3-10)

2. Management in relation to parasitism. Two groups of lambs were weaned at about 60 days of age and grazed on relatively clean and on light to moderately contaminated pastures. Lambs grazing with their mothers on contaminated pastures until weaning at 120 days and on the same pastures after weaning were treated by drenching with phenothiazine, with access to a 1:9 phenothiazine mineral mixture or only as mineral mixture, and by drenching with thiabendazole, with access to a 1:49 thiabendazole-mineral mixture or to only a mineral mixture. Parasitism in the first two groups were nil on July 1. Fecal egg counts in the other groups were 996, 1825, 2211, and 1630 haemonchus eggs per gm. and 142, 31, 147, and 85 strongyloides eggs per gm., respectively. No significant differences in average body weight of the lambs were found on July 1. (AH b3-11)

D. Management Practices, Equipment and Facilities

1. Continuous vs. night breeding in producing fall born lambs. No difference was found in percent of ewes lambing but ewes mated at night lambed two days earlier and had more twins than ewes mated continuously. (AH b3-7)

2. Time of parturition in ewes. Data over a 5-year period on 1,270 ewes showed significant period effects for time of parturition where ewes of all ages and types of birth were pooled. Peaks occurred between 9 and 12 a.m. and 3 and 6 p.m. Period effects were due to the parturition pattern of ewes 3 years and older and were largely a result of variations in frequency of multiple births of these ewes. (AH b3-6)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Digestion and Metabolism

Lindhahl, Ivan L. and Terrill, C. E., 1963 Use of pelleted roughage in the feeding regime for breeding sheep. J Anim. Sci. 22, 953-955. (AH b2-5)

Price, D. A., Humphrey, R. D., and Frederiksen, K. R. 1963. Response of ewe lambs to hay quality and feeding method. J. Anim. Sci. 22: 844 (Abstract) (AH b3-9)

Forage Evaluation and Utilization

Reynolds, P. J. Jackson, Charlie, Jr., Lindahl, I. L., and Henson, P. R. 1964. Consumption and digestibility of crownvetch by sheep. Paper presented at Crownvetch Symposium, University Park, Penna., July 8 and 9, 1964. Abstract to be published in proceedings of Symposium. (AH b2-7)

Range and Pasture Management

Price, D. A., Lindahl, I. L., Frederiksen, K. R., Reynolds, P. J. and Cain, C. M. Jr., 1964. Nutritive quality of sheep's diet on tall forb range. J. Anim. Sci. 23: 603 (Abstract). (AH b3-9)

Management Practices, Equipment and Facilities

Lindhahl, Ivan L. 1964. Time of parturition in ewes. Animal Behaviour 12: 231. (AH b3-6)

AREA NO. 16: SWINE--BREEDING

Problem. Improvements in the heredity of swine depend on the intensity and accuracy of selection practiced in choosing breeding animals and on the choice of a mating system that maximizes the rate of genetic improvement. Crossbreeding swine for the production of market animals has so proved its value that over 90% of the pigs marketed in the United States are currently some kind of crossbreds. Research in swine breeding thus is faced with the dual challenge of developing foundation seed stock populations that yield maximum improvement for commercial production and also devising methods that fully utilize the genetic potential of available seed stocks for further increases from heterosis and hybrid vigor generally shown by crossbred pigs. It is essential that experimental work continue the development of genetic facts and practical methods that breeders can use to develop better and more efficient seed stock strains. Particular effort is needed on effective genetic means for efficient production of pork with more lean and less fat without sacrificing gains in other production traits.

USDA AND COOPERATIVE PROGRAM

This is a continuing program of basic and applied research conducted by geneticists and animal husbandmen to elucidate genetic principles and develop effective breeding systems that will result in further increases in the efficiency of swine with respect to productivity and carcass value. This is a coordinated research effort involving the USDA and several State agricultural experiment stations. Research is in progress at Beltsville, Maryland, cooperatively with the Montana Agricultural Experiment Station at Miles City, Montana, and at the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa. The Regional Laboratory includes cooperative projects at State Agricultural Experiment Stations in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Oklahoma, South Dakota, and Wisconsin. Investigations on genetic principles, selection, and breeding systems include work with swine and also with laboratory animals on important performance traits, their heritabilities, and their phenotypic and genetic correlations. The results of such studies provide the basis for emphasis given to different complex traits and the underlying factors in evaluating different systems for achieving genetic changes. Traits of major interest include productivity of dam, viability, growth rate, feed efficiency, carcass composition, and quality of meat.

Cooperative research with the Food and Drug Administration is in progress to investigate the response of "miniature" swine to further reduction in body size from selection and their usefulness for toxological tests as well as basic studies in nutrition and genetics.

The Federal scientific effort in this area totals 9.5 professional man-years. Of this number, 2.2 are devoted to genetics and interrelations of performance traits, 5.2 to selection and breeding systems, and 2.1 to program leadership.

A grant with the College of Agriculture, Poznan, Poland, provides for investigations on red blood cell and serum antigens to establish the mode of inheritance and relative frequencies of these antigens in certain breeds of swine. Its duration is for five years, 1962-1966, and involves PL-480 funds.

PROGRAM OF STATE EXPERIMENT STATIONS

Swine breeding research uses experiment station animals, herds of cooperating swine producers, and litters on tests in swine testing stations. Economic traits being considered include growth rate, feed deficiency, maternal ability, litter size, viability, and carcass yield and quality. Areas of investigation include estimation of genetic parameters, comparison of methods of selection and breeding systems, and evaluation of crossbreeding. In some instances, interrelationships of genetics and certain environmental factors such as housing, nutrition, and management are also being studied. Genetic parameters of interest include heritability (the degree which traits are influenced by genetic factors) of the above economic traits and the genetic and environmental relationships between these traits.

Much of the research on evaluation of breeding systems concerns the effectiveness of mass selection based on one or more of the economic traits. In addition, evaluation of recurrent selection to increase combining ability is being conducted. Meatiness of the carcass is one of the most important economic traits. Selection programs have recently been initiated to select for decreased backfat at market age. Crossbreeding in swine has been widely adopted by the industry. Research is in progress to determine the relative degrees of hybrid vigor resulting from crosses between specific breeds and strains and the value of selection within strains for the ability to combine well in crosses. Various systems of crossbreeding including crisscrossing, three-way crosses, and multiple breed crosses are being evaluated. Efforts are also under way to develop new breeds from crossbred foundations, and attempts are being made to maintain the superiority of crossbreds for every trait.

The North Central stations and Oklahoma conduct swine breeding research in cooperation with the USDA through the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa.

The total research effort on swine breeding research by the State agricultural experiment stations is 23.6 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Genetic and phenotypic parameters. Skeletal data obtained on high-fat, low-fat, and control line Duroc and Yorkshire pigs showed Yorkshire pigs significantly exceeding Duroc pigs in both number of thoracic and lumbar vertebrae and number of ribs. Line differences in Yorkshires did not differ significantly, but in Durocs both low-fat and control line pigs significantly exceeded high-fat pigs in the two traits, indicating that upward selection for backfat thickness in Durocs definitely resulted in a reduction in both average number of vertebrae and average number of ribs. Sex differences were negligible in all lines. (AH al-12)

In a study of sexual maturity, S-LL and S-BB gilts, representing two select strains currently being used in a reciprocal recurrent selection program, averaged approximately 18 days less in age at first estrus than their respective C-LL and C-BB control groups. These advantages in favor of the two select strains point in the same direction as those shown last year by S-BL and S-LB crossbred gilts over the same two control groups, and suggest that selection for specific combining has had the effect of reducing age at first heat in both crossbred and straightbred gilts produced by select straightbred females. (AH al-13)

Efficiency of feed utilization expressed as weight gain per pound of feed and its relation to daily gain, daily feed consumption, percent lean cuts in the carcass, and backfat thickness was obtained from data on 108 straightbred and crossbred Yorkshire and Duroc pigs in individual feeding tests from about 85 days of age to 210 pounds average weight. Heritability estimates indicated that over half of the total variance in efficiency, growth rate, and feed consumption was accounted for by additive genetic effects. Genetic correlations among the five variables had rather large confidence intervals, but suggested important genetic interdependence for growth rate, feed efficiency, and backfat thickness. Positive genetic correlations were found between gain and efficiency (.32) and between gain and backfat thickness (.69) and a large negative (-.92) between efficiency and backfat thickness. (AH al-10)

Feed efficiency, gain, and feed consumption from 42 to 154 days of age studied with data from 999 litters of pigs in six crops over a three-year period showed linear correlations of $-.28 \pm .03$ between efficiency and feed consumption and $.15 \pm .03$ between efficiency and gain. This latter value is lower than values generally observed with initial and final weight constant. This suggests that in age-constant tests fast growers may be less efficient due to increased maintenance requirements, while in weight-constant tests they reach a given weight in less time and thus save feed for maintenance. It appears from this that feed efficiency should be measured with weight held constant. Heritability of feed efficiency estimated from paternal half-sib differences among litter means was $.27 \pm .06$. (AH al-22)

Data from 461 Yorkshire pigs with three levels of inbreeding (0, 33, and 49%) showed an interaction of sex with inbreeding. For noninbred pigs, the difference in weight at 154 days of age between barrows and gilts was 17.1 pounds. This difference became smaller as inbreeding increased. For each 10% increase in inbreeding, the decline in average weight at 154 days was 8.0 pounds for barrows and 5.7 for gilts. Average differences at 200 pounds liveweight between full-sib barrows and gilts (26 pairs) showed gilts to be nine days older and .19 inches longer with slower test gain (.2 lbs/day), less backfat (.14 inches), more loin eye (.46 square inches), and higher percent of ham and loin (1.9). (AH al-23)

Efficiency of gain and phenotypic correlations among postweaning traits were investigated with data from 1,132 group-fed pigs sired by 283 boars and 184 boars fed individually. Phenotypic correlations of .36, -.24, and .05 between average daily gain and average test weight, daily gain and feed per pound of gain, and average test weight and feed per pound of gain, respectively, were obtained from the group-fed pigs. Multiple regression of feed per pound of gain on the other two variables accounted for 8% of the variance in efficiency. Of various equations developed to estimate efficiency those that included daily gain and daily feed consumption accounted for 94% of the variance in feed per pound of gain, while those that omitted daily feed consumption accounted for less than 23% of the variance. Phenotypic correlation showed feed per pound of gain decreasing as gain increased ($r = -.40$) and increasing as feed per day increased ($r = .63$). The results indicate that efficiency of gain cannot be estimated with much precision from observations that do not include average daily feed consumption. (AH al-8)

Preliminary study of the relation of lean cuts to liveweight, carcass weight, and backfat probe with data from 101 barrows ranging in weight from 159 to 265 pounds indicated that either liveweight or carcass weight alone gave a fairly accurate estimate of pounds of lean cuts. On the other hand, backfat probe was the better indicator of percent of lean cuts. Multiple regression with weight and probe as independent variables was only slightly better than linear regression on the better variable in each case. Liveweight alone accounted for 82% of the variance in pounds of lean cuts, and backfat probe alone accounted for 56% of the variance in percent of lean cuts. This indicates that the most useful information on carcass composition is obtained with backfat probe when weight is held constant. (AH al-20)

Heritability of backfat estimated from response to selection was .74. Other respective heritabilities based on data for 331 pigs using regression on dam and regression on midparent were: average daily gain, .17 and .22; weaning weight, -.17 and -.05; total score for desirability, -.10 and .17; and feed per pound of gain, .15 and .10. Genetic correlations of backfat were .70 with average daily gain, -.93 with total score, and -.46 with feed per pound of gain. Other genetic correlations were small. Correlated responses from selection indicate a genetic relation of .72 between backfat

and daily gain. It appears that reduction in backfat may reduce growth rate and efficiency of feed utilization. The repeatability of judges in scoring for meatiness was .76. (AH al-21)

A study of muscle quality characteristics in the longissimus dorsi muscle in 87 Yorkshire and 55 Duroc pigs showed Yorkshires averaging higher in pH value, color-firmness quality scores, moisture, myoglobin, and fiber diameter; and lower in initial glycogen level and ether extract. Expressible moisture was similar for the two breeds. Pooled intragroup correlations of color-firmness quality scores were: with pH .35, with myoglobin concentration .25, and with expressible moisture -.17. Correlations of pH of the longissimus dorsi muscle with glycogen and myoglobin concentrations were -.30 and .34, respectively. In the Duroc breed, fiber diameter was correlated with ether extract and with percent moisture .36 and -.45, respectively. Nonsignificant correlations were observed among these traits in the Yorkshire breed and on an intragroup basis.

Heritability estimates indicated strong additive genetic influence (h^2 mostly above .50) on pH, expressible water, ether extract, percent moisture, myoglobin, and fiber diameter. Heritability was essentially zero for color-firmness quality score and initial glycogen content. Some of the higher genetic correlations within the Duroc breed were pH with myoglobin ($.87 \pm .20$) and with fiber diameter ($.88 \pm .25$), myoglobin with percent moisture ($1.12 \pm .14$) and with ether extract ($1.26 \pm .33$), and ether extract with percent moisture ($.95 \pm .05$). In the Yorkshire breed genetic correlations with one exception (quality score with ether extract, $-.79 \pm .39$) were generally small. (AH al-10)

2. Pilot experiments. Selection for postweaning growth (18-42 days) in mice produced a more or less linear increase in growth which in the 17th generation was about six times the additive genetic standard deviation and about 43% of the original average growth. Heritability of growth was estimated at $.24 \pm .07$ for males and $.26 \pm .08$ for females. Growth in the selected population was about 3.5 g. greater than in the F_1 cross of the progenitor inbred lines. This suggests average dominance is in the direction of alleles favorable for growth but far from complete dominance. Crosses of the line selected for growth rate with an unselected inbred line over 20 generations of selection showed increases approximately one-half that achieved from mass selection and thus provided no definite evidence of nonadditivity of growth. Estimates of genetic correlation between growth rate and litter size have been positive. At the end of 22 generations of selection for growth rate, average litter size is 1.5 mice larger than at the start. The correlated response of litter size to selection for growth rate has amounted to one-tenth of a mouse per generation of selection with no evidence of reduction in the genetic correlation between growth rate and litter size. (AH al-17)

3. Genotype-environment interactions. In the second year of selection for less backfat under different environmental conditions response to selection has been similar for backfat thickness, rate of gain, litter weaning weight, and feed efficiency. (AH al-21)

The importance of heredity-environment interactions for carcass traits was studied with three kinds of crossbred pigs on three different diets with observations on 180 pigs for slaughter weight, carcass weight, backfat thickness, ham weight, five primal cuts, loin-eye area, carcass length, and estimated percents of lean, fat, and bone. Diets significantly influenced all traits except loin-eye area, loin weight, and ham weight. Breeding groups differed significantly for all traits except belly weight and liveweight at slaughter. Significant breed group x diet interactions was observed for ham weight, loin-eye area, and carcass length. (AH al-17)

B. Selection and Breeding Systems

1. Selection for single traits. Backfat thickness in ninth generation high-fat, low-fat, and control line Duroc pigs averaged 2.00, 1.18, and 1.52 inches, compared with 1.46, .99, and 1.22 inches in seventh generation high-fat, low-fat, and control line Yorkshire pigs. Realized heritabilities now stand at .53 and .39 for high- and low-fat Duroc pigs, and .32 and .47 for high- and low-fat Yorkshire pigs. Carcass data obtained on samples of pigs slaughtered at about 220 pounds showed high-fat, low-fat, and control line Durocs averaging 2.56, 1.58, and 2.07 inches in backfat thickness; 27.1, 29.6, and 28.7 inches in length of carcass; 2.52, 3.65, and 3.43 square inches in loin-eye muscle area; 34.6, 39.8, and 38.1% in yield of lean cuts; 20.4, 12.6, and 15.1% in yield of fat cuts; and 11.8, 9.7, and 10.3% in yield of bacon. Seventh generation high-fat, low-fat, and control line Yorkshire pigs averaged 2.03, 1.27, and 1.56 inches in backfat thickness; 29.8, 29.8, and 30.1 inches in length of carcass; 3.48, 4.52, and 3.50 square inches in loin-eye muscle area; 37.7, 42.4, and 39.8% in yield of lean cuts; 15.9, 10.6, and 13.6% in yield of fat cuts; and 11.4, 10.0, and 11.0% in yield of bacon.

Data illustrating the effects of selection on the composition of individual cuts showed that dissected hams of ninth generation high-fat, low-fat, and control line Durocs averaged 6.2, 8.9, and 8.2 pounds in lean meat; 5.2, 4.0, and 4.2 pounds in fat; and 1.1, 1.5, and 1.3 pounds in bone. The hams of seventh generation high-fat, low-fat, and control line Yorkshire pigs averaged 8.0, 10.5, and 8.8 pounds in lean meat; 4.0, 3.5, and 3.8 pounds in fat; and 1.3, 1.5, and 1.4 pounds in bone. These results show quite clearly that the selection practiced for backfat thickness has brought about rather marked changes in both total weight and lean to fat ratio of the pig's hams, with the hams of Yorkshire pigs averaging more lean meat, less fat, and less bone than those of similarly selected Duroc pigs. (AH al-12)

Comparisons between lines selected for a single trait and a control line showed after three generations little evidence of real differences in efficiency, 154-day weight, backfat thickness, and production index. However, disease problems in all herds resulted in rather small selection differentials. (AH al-22)

Ten generations of selection for reduced backfat in a Duroc line produced 200 pound pigs in 1963 with an average backfat of 1.21 inches as compared with an average of 1.42 inches in 1953. Selection differentials averaged .14 of an inch over the 10-year period. Carcass length and loin-eye area increased as backfat was reduced. (AH al-9)

Meatiness in one herd has responded to individual selection for backfat thickness and progeny testing for carcass traits. Average changes per year amounted to +.3 inches in body length, -.04 inches in backfat thickness, +1.6% in ham and loin, and +.22 square inches in loin-eye area. (AH al-22)

Four generations of mass selection for reduction in backfat thickness show average achievement from selection amounting to about one-third of the amount selected for, with greater progress in the first two than in the last two generations. Average backfat thickness at 175 pounds in the initial herds was 1.10 inches and after the fourth generation of selection it was .91 inches. Analysis of data from the first two generations of selection suggested a slight decrease in daily gain while sow productivity, ham index, percent lean cuts, pounds of lean per day of age, and fat trim showed little or no change. (AH al-21)

2. Selection for combining ability. Litters produced by two groups of straightbred females (BB and LL) selected on the basis of their cross progeny performance exceeded control strain litters by 1.3 and .7 pigs or by 16 and 8% in litter size at weaning, and by 28 and 55 pounds or by 8 and 16% in litter weight at weaning. Litters produced by single cross females (BL and LB) exceeded control litters by 1.6 and 1.7 pigs or by 24 and 25% in litter size at weaning and by 76 and 96 pounds or by 31 and 38% in litter weight at weaning. Single cross litters generally showed greater advantages over control line litters for both litter size and litter weight at birth and at weaning than was shown by single cross litters in earlier years, suggesting that the amount of heterosis shown by these traits is increasing as selection for specific combining ability progresses. (AH al-13)

In the Miles City project, sixth cycle single cross pigs produced by reciprocally crossing fifth cycle Montana No. 1 and Yorkshire animals exceeded Montana No. 1 control strain pigs by .36 pounds or by 24% in daily gain from weaning to a final weight of about 225 pounds. This advantage for crosses is slightly greater than that shown by fifth cycle crosses. (AH al-11)

Progeny of purebred and crossbred sires were compared for performance in the feedlot and for carcass traits. Variances of progeny performance were similar for both kinds of sires and indicate that use of crossbred sires did not increase variation among progeny. In general, progeny of crossbred sires performed at about the same level as those sired by purebreds from parental breeds used to make the crossbreds. (AH al-17)

In an experiment designed to evaluate sires on the basis of their purebred and crossbred progenies, the ranking of contemporary sires was somewhat altered for the two kinds of progeny. This suggests that specific combining ability was present and perhaps of sufficient magnitude and frequency to justify its utilization in a breeding program. (N.C.)

Selection for combining ability among three lines has shown improvement. Over the past four years all tested sires have produced pigs which averaged at 200 pounds over 4 square inches of loin-eye area and less than 1.43 inches of backfat. Single cross gilts and purebred gilts farrowing single cross litters both had larger litters than the controls. There was some evidence of loss of heterosis by the control line which appears to be approaching equilibrium. (AH al-8)

3. Development and evaluation of inbred lines and crosses. Data on 173 litters from four one-sire lines and 97 litters from a two-sire line of Montana No. 1 swine maintained at Miles City, Montana, from 1947 through 1954 showed the one-sire lines declining in all litter traits studied, with the linear regressions on years averaging $-.22$ and $-.34$ pigs for litter size at birth and at weaning and $-.4$ and -9.7 pounds for litter weight. The corresponding regressions for the two-sire line were $-.08$ and $.02$ pigs and $-.3$ and $.5$ pounds for litter size and litter weight, respectively. The positive values for the two-sire line point in the opposite direction from the inbreeding decline expected from the calculated regressions on inbreeding and the inbreeding increase per year, while the negative values obtained for the two sets of lines were from about one-half to three-fourths as large as the corresponding decline expected on this basis. (AH al-11)

A miniature line of swine has been developed from animals obtained in the wild state from Catalina Island, Alabama, and Louisiana in 1949 and from Guam in 1958 with continuous selection for reduced size. Liveweight has been reduced by about 30% and present expected weight at 140 days of age is about 40 ± 20 pounds. These animals at one year of age are about one-half the size of conventional pigs the same age. Actual reduction in 140-day weight averaged about 3.2 pounds per generation from 1950 through 1961. Estimates of heritability increased from 16% to 41% after the introduction of stock from Guam. There is no evidence that response to selection has diminished in recent generations. (AH al-17)

Matings between two inbred lines of Yorkshires inbred rapidly from four samples of superior germ plasm produced crossbred progeny superior to both lines for litter size at weaning and weight at 154 days of age. (AH al-23)

Inbreds and top crosses with variable relationship to the inbreds produced in a "convergent improvement" breeding system over 10 years provided estimates of the influence of inbreeding on various traits. In agreement with other studies, inbreeding depressed litter size, viability, and growth rate but had little effect on carcass traits measured at 200 pounds live-weight. (AH al-9)

Evaluation of samples from the Yorkshire breed by rapid inbreeding, line testing in crosses, and recombination in lines permitted early sorting among lines for desirable total performance. The lines performed satisfactorily and line differences for several traits were observed. (AH al-9)

4. Environmental influences as related to performance. Repopulation of a herd by a modified "specific pathogen free" technique in 1961 led to a lower incidence of disease, improved reproductive performance, some reduction in mortality, and improved growth rate primarily from the reduction of the number of runt pigs. A gradual increase in disease level has occurred with Pasteurella, Corynebacterium, and Bordetella identified as present in the herd. (AH al-22)

A significant growth stimulus was observed when Auero S-P 250 premix was added to the ration for the first four to six weeks after weaning. There was a carryover effect through the finishing period and a small improvement in efficiency which produced slightly cheaper gains from weaning to market weight. (AH al-8)

5. Gene pools. A gene pool of the older breeds will be completed in 1965 when the Large Black and Hereford are brought in. Several samples recently added include the Mule Foot, Guinea, and European Wild hog. The average performance of the two lines in this gene pool has been very satisfactory with respect to litter size, growth rate, average age at puberty, and backfat thickness. Arrangements are now underway to establish a gene pool of the new or more recently formed breeds. (AH al-20)

6. Crossbreeding and heterosis. Flushing straightbred and crossbred gilts from puberty to second estrus increased the average ovulation rate by 2.9 ova, but produced only a slight increase in the number of embryos surviving at 28 days gestation. Crossbred gilts (YD and DY) averaged about seven days younger at first estrus than straightbred (DD and YY) gilts. Age at puberty and response to flushing by Yorkshire (YY), Duroc (DD), and crossbred gilts (YD and DY) showed crossbreds exhibiting first estrus seven days earlier than straightbreds (DD = 212, YY = 217, DY = 205, and YD = 210). Ovulation rates and embryo survival showed no conclusive differences between the two kinds of gilts with overall average estimates of 14.2 ova at second estrus and 10.6 embryos at four weeks gestation. (AH al-20)

In reciprocal crosses between the Landrace and the Poland China breeds, Landrace sows produced larger litters and smaller pigs at birth, 56, and

154 days of age. Performance of crossbred sows (LP and PL) mated to Duroc boars showed maternal influence in favor of Poland China mothers for litter size and pig weight at all three ages. Another reciprocal cross between crossbreds (LP and PL) and Durocs (DD) showed crossbred dams superior to Durocs for litter size and pig weight. Pigs from Duroc sows were shorter and had more backfat. These results indicate that a crossbreeding program should include at least three breeds to obtain hybrid vigor in both the dam and the pigs. (AH al-21)

C. Performance and Progeny Testing

The Wisconsin Swine Selection Cooperative completed its 19th year of continuous on-the-farm testing in 1963. This program resulted from and has been based on findings in the Regional Swine Breeding Laboratory. It included 3,753 pigs farrowed in 359 litters in 1963 with 2,922 raised to five months of age. Comparison of averages in 1955 with those of 1963 shows that average loin-eye area had increased from 3.89 to 4.31 square inches and average backfat had decreased from 1.74 to 1.39 inches. In 1955, no pigs had less than 1.39 inches of backfat and only five had more than 4.31 square inches of loin eye. (AH al-10)

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Genetics and Interrelations of Performance Traits

- Allen, E., Forrest, J. C., Bray, R. W., Briskey, E. J., First, N., and Chapman, A. B. 1963. Porcine muscle properties II. Heritability and genetic correlations. (Abstr.) J. Animal Sci. 22:1112. (AH al-10)
- Biswas, D. K., Hunt, P. V., Chapman, A. B., First, N. L., and Self, H. L. 1963. Feed efficiency and carcass desirability in swine. (Abstr.) J. Animal Sci. 22:1109. (AH al-10)
- Comstock, R. E., Singh, M., and Enfield, F. D. 1963. Selection for growth in mice: crossbred performance. (Abstr.) J. Animal Sci. 22:1109. (AH al-17)
- Forrest, J. C., Allen, E., Briskey, E. J., Chapman, A. B., First, N., and Bray, R. W. 1963. Porcine muscle properties I. Correlations between components and influence of breed. (Abstr.) J. Animal Sci. 22:1114. (AH al-10)
- Heidenreich, C. J., Garwood, V. A., and Harrington, R. B. 1964. Swine growth and composition as associated with total semen cholesterol. J. Animal Sci. 23:496-498. (AH al-18)
- Magee, W. T. 1963. The relationship between the effect of inbreeding and sex on 154-day weight in swine. (Abstr.) J. Animal Sci. 22:820. (AH al-23)
- Magee, W. T. 1964. Interaction between the effects of sex and inbreeding on 154-day weight in Yorkshire swine. J. Animal Sci. 23:444-446. (AH al-23)
- Park, Y. I., Lush, J. L., and Hazel, L. N. 1963. Age-constant feed efficiency of pigs. (Abstr.) J. Animal Sci. 22:1109-1110. (AH al-22)

- Peters, W. H., Hetzer, H. O., and Kincaid, C. M. 1963. Age at puberty and its influence on sow productivity. Annual Meeting, North Atlantic Section, ASAS, Morgantown, W. Va., Mimeograph. (AH al-13)
- Rahnefeld, F. W., Boylan, W. J., Comstock, R. E., and Singh, M. 1963. Mass selection for post-weaning growth in mice. Genetics. 48:1567-1583. (AH al-17)
- Salmela, A. B., Rempel, W. E., and Gates, C. E. 1963. Reaction of three kinds of single-cross pigs to three levels of feed intake. II. Carcass characteristics. J. Animal Sci. 22:886-889. (AH al-17)
- Turner, J. W. and Whatley, J. A. (Jr.). 1964. Predicting efficiency of gain in swine. (Abstr.) J. Animal Sci. 23:307. (AH al-8)

Selection and Breeding Systems

- Hetzer, H. O., Harvey, W. R., and Peters, W. H. 1963. Selection for high and low fatness in Duroc and Yorkshire swine. 11th Internat. Congress of Genetics, The Netherlands, Proc. Vol. 1:268 (Abstr.). (AH al-12)
- Pani, S. N., Day, B. N., Tribble, L. F., and Lasley, J. F. 1963. Maternal influence in swine as reflected by differences in reciprocal crosses. Mo. Agric. Exp. Sta. Res. Bull. 830. (AH al-21)
- Rempel, W. E., Comstock, R. E., and Enfield, F. D. 1964. Comparison of performance of crossbred pigs sired by purebred and crossbred boars. J. Animal Sci. 23:87-89. (AH al-17)
- Rempel, W. E., and Dettmers, A. E. 1963. Progress in the development of a miniature pig. (Abstr.) J. Animal Sci. 22:1110. (AH al-17)
- Short, R. E., Zimmerman, D. R., and Sumption, L. J. 1964. Heterotic influence on reproductive performance in swine. (Abstr.) J. Animal Sci. 22:868. (AH al-20)
- Zoellner, K. O., Lasley, J. F., Tribble, L. F., and Day, B. N. 1963. Selection for thinner backfat in swine. Mo. Agr. Exp. Sta. Res. Bull. 831. (AH al-21)
- Short, R. E. 1963. Influence of heterosis and plane of nutrition on reproductive phenomena in gilts. M.S. Thesis. Univ. of Nebr., Lincoln. (AH al-20)

AREA NO. 17: SWINE--PHYSIOLOGY

Problem. Continued improvement in efficiency of swine production is dependent on new information regarding the physiology of growth and reproduction as well as environmental adaptation. Particularly in the field of swine fertility, considerable knowledge is needed regarding the development of artificial insemination including semen and ova preservation and storage. Fertility problems in boars and sows seriously plague the efforts of the industry to produce pork at lowest cost. Development of new genetic aids for improvement of swine requires additional understanding of the physiological processes, particularly those involved in the growth and production of high quality lean meat.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by physiologists, biochemists, and animal husbandmen on basic and applied problems in the physiology of reproduction, artificial insemination, and the physiology of growth and development, particularly with respect to the mechanisms involved in fat deposition, muscular development, and inborn metabolic differences. Research in progress at Beltsville, Maryland, is aimed primarily at the development of basic knowledge about swine physiology from the study of animals with contrasting genetic differences. Cooperative studies are also included in projects of the Regional Swine Breeding Laboratory at Missouri, Nebraska, and other cooperating stations as opportunities arise with respect to personnel and facilities.

The Federal scientific effort on research in this area totals 2.4 man-years. Of this number, 0.3 is on physiology of reproduction, 1.8 on physiology of growth and development, and 0.3 on program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

Much of the current program of research in this area is based on the thesis that increased reproductive efficiency in swine is dependent primarily upon an understanding of the nutritional and physiological influences on variability of ovulation rate and embryonic survival. Fundamental studies are underway designed to yield information on endocrine events occurring at the time of ovulation, and physiology of the uterine tract conducive to maximum embryonal survival. The effect of the level of nutrition at various stages of growth and development on ovulation rate and embryonal survival is also being studied.

Artificial insemination shows considerable promise in swine as it has in other species. Problems peculiar to swine must be solved, however, before the technique has practical application. Swine spermatozoa are relatively shortlived in vitro, and the volume and concentration of the ejaculate

are quite variable. These and other problems under study include the effects of the accessory glands on semen quality, and yield and composition of sow's milk and the effect of lactation stress on subsequent reproduction.

Stress factors under study include high and low ambient temperature, optimum temperature and humidity at different stages of development, and interrelationships of environmental temperature with nutrition and environment. The effects of cooling of males and females on conception rate and prolificacy are also being investigated.

Additional studies in this area, including design of housing and equipment, are being conducted in cooperation with Agricultural Engineering including a new regional project, NC-72, Swine Housing Environment.

State stations are investigating the influence of inbreeding and crossbreeding on physiological mechanisms affecting growth and fertility. One station is studying differences in carcass characteristics between barrows and gilts with particular reference to time and rate of development, and the influence of feeding low levels of hormones on sex-influenced growth pattern. Extensive basic research is concerned with the nutrition and physiology of the developing swine fetus. Changes in total serum protein and serum protein electrophoretic patterns during fetal development are being investigated and histological changes of the gastrointestinal tract as they occur during development of the fetus are being characterized.

The total State scientific effort devoted to swine physiology research is 11.8 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Synchronization of estrus. Effective synchronization of estrus has been achieved by feeding a synthetic non-steroid compound (1- α -methylallylthiocarbamoyl-2-methylthiocarbamoylhydrazine, ICI 33,828) to gilts. About 85% of the animals receiving .79 mg. of this compound per kilogram of weight expressed estrus from five to seven days after treatment was stopped. Conception rate was 70% and no adverse effect on ovarian function or fertility was observed. The average number of embryos observed on autopsy at 16 to 49 days gestation was 9.9. Further study is needed on this compound, but it appears that this work offers for the first time the possibility of a practical way to utilize artificial insemination in swine for breeding and farrowing on a fixed time schedule. (AH al-19)

2. Factors influencing estrus and fertility. Implants of progesterone and estrogen on 11th day after mating produced a slight improvement in embryo survival, but a second similar trial with gilts implanted on the 7th day after mating showed no improvement over controls. In another experiment with 117 females, intramuscular injection of pregnant male

serum (PMS) and human chorionic gonadotrophin (HCG) induced superovulation and increased the average number of living embryos in gilts. Respective average ovulation rates and numbers of living embryos per litter were 23.8 and 8.8 for five treated gilts in comparison with 10.7 corpora lutea and 8.8 embryos for 13 controls. In a third experiment fertilized ova moved from the oviducts into the uterine horn from 66 to 90 hours after the onset of estrus. This was from 36 to 60 hours after estimated time of ovulation. Recovery of 83% of the ova from 55 females at intervals of time ranging from 30 to 108 hours after onset of estrus provided information on embryo development and transport which can be used for more effective study in this area. (AH al-21)

Energy levels and method of restricting energy intake for gilts during the breeding season which produced average daily gains for four treatments of .44, 1.37, 1.42, and 2.01 per head per day showed respective averages per gilt of 14.1, 15.8, 15.4, and 15.5 ovulations. This indicates that the group with the lowest gain was the only one showing an adverse effect on ova production. Method of feeding, individual versus group, had little influence on ovulation rate. (AH al-20)

B. Physiology of Growth and Development

1. Physiological differences under genetic control. Basic information to serve as a foundation for further research in swine physiology was obtained from pigs in six lines of Durocs and Yorkshires selected for backfat thickness over nine and seven generations, respectively. Average backfat thickness for these lines ranged from about 1.0 inch to over 2 inches. Weights were taken for liver, kidney, heart, pancreas, thyroid, adrenal, pituitary, stomach, and small intestine. Small intestine length and blood glucose levels were also measured. The thyroid and pituitary glands in the Durocs were significantly smaller than in the Yorkshires. However, the Yorkshires had significantly smaller pancreases, livers, adrenals, stomachs, and small intestines. In both breeds the size of the heart decreased as the amount of backfat increased. The weight of the pancreas in selected lines of both breeds was larger than the controls. Yorkshires averaged approximately one more vertebra and one more rib than Durocs. The incidence of stomach ulcers was 37.5%. These data indicate that selection has introduced physiological differences which can provide a sound basis for specific investigations of some genetically controlled physiological processes and their relation to productivity. (AH al-19)

2. Gastrectomized pigs. In cooperative exploratory work with the National Institutes of Health, gastrectomized swine were used to study the influence of the absence of the stomach on degenerative changes in the central nervous system similar to those noted in human patients afflicted with amyotrophic lateral sclerosis. Ten pigs were gastrectomized. Six survived and showed clinical symptoms that suggested involvement of the central nervous system. Histological examination of tissue from the central nervous system of one pig showed no apparent differences from controls.

Clinical observations 20-24 weeks postgastrectomy included hypersensitivity, persistent tremor, spastic paralysis, unsteady gait, and adducted hind legs. All animals exhibited either transitory or permanent arrest of growth associated with the above clinical symptoms. A progressive development of both hypochromic and microcytic anemia was observed. This suggests that utilization of iron may have been a major factor in the overall response of these animals to gastrectomy. (AH al-19)

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

Day, B. N., Romack, F. E., and Lasley, J. F. 1963. Influence of progesterone-estrogen implants on early embryonic mortality in swine.

J. Animal Sci. 22:637-639. (AH al-21)

Gibson, E. W., Jaffe, S. C., Lasley, J. F., and Day, B. N. 1964. Reproductive performance in swine following superovulation. (Abstr.) J.

Animal Sci. 22:858. (AH al-21)

AREA NO. 18: SWINE--NUTRITION AND MANAGEMENT

Problem. The changing demands of the consumer for pork with a high proportion of lean are requiring major changes in the nutrition and management of swine. Furthermore, the use of materials other than lard has greatly reduced the demand for fat-type hogs. Along with the change in genetic makeup which must be made, basic facts concerning metabolic functions require investigation, and the basic nutritional factors which influence growth and carcass composition need to be identified and evaluated. These require information on quantitative and qualitative requirements at various growth stages and the changes in requirements to adjust for altered levels of other nutrients or modified environment. To meet the competition of other foods, including other meats, the nutrition and management of swine must constantly be aimed at improvement of feed and labor efficiency.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen investigating basic and applied problems in swine production related to nutrition, metabolism, and management. Work is in progress at Beltsville, Maryland, and cooperatively with the Agricultural Engineering Division and the National Institutes of Health, as well as through informal collaborative agreements with the Food and Drug Administration and the Southern Utilization Research and Development Division. These studies contribute to the establishment of nutrient and mineral requirements and the relation of different components of the diet to each other; to the development of more efficient and economical rations; to the relation of genetic differences to dietary requirements; and to the role swine may have as an experimental animal for the investigation of health and dietary problems in man.

The total Federal scientific effort in this area amounts to 7.8 professional man-years. Of this number, 2.0 are devoted to digestion and metabolism, 0.5 to concentrates, evaluation, and utilization, 1.5 to feeding methods, 2.0 to nutrient requirements, 1.0 to management practices and equipment, and 0.8 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The States are engaged in both basic and applied research in swine nutrition. This research is concerned with the determination of nutritive requirements of swine at various stages of growth for specific amino acids, minerals, vitamins, protein, and energy and the changes in these requirements that result from altered levels of any of these nutrients. Other aspects are concerned with the determination of digestibility coefficients, absorption and retention, effect of diet on antibody production, and the use of feed additives such as hormones, enzymes, high copper levels, and antibiotics to improve growth and feed efficiency.

The requirements of the baby pig are being studied in order to develop economical practical liquid or dry starter rations and to investigate the effect of dietary ingredients on the palatability of baby pig rations.

Studies are in progress to determine the value of forage as an economical mineral, vitamin, and protein source as well as the utilization of these high roughage diets as a means of restricting feed intake of growing or gestating swine. Consideration is given to the effects of the variation in fiber levels in the ration on the growth rate and carcass quality, the nutritive requirements of pigs on dry lot versus those on pasture, and the effect of different forage pastures and dry lot feeding during gestation on number and weight of pigs at birth and weaning.

Other aspects of swine nutrition are concerned with improving the nutritional quality of rations utilizing locally grown feedstuffs by vitamin, amino acid, enzyme, or antibiotic supplementation.

The ways of managing the swine enterprise for more efficient operation are being investigated. Special attention is given to methods and levels of feeding gestating and lactating sows, management of suckling pigs, age of weaning, and the relative merits of pasture or drylot feeding.

Total research effort on swine nutrition and management is approximately 35.9 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

Effects of energy level on pigs with genetic differences in performance, type, and breed. The response to different levels of energy by Duroc and Yorkshire lines selected over several generations for either maximum or minimum backfat was measured with individual feeding trials and physical separation of carcasses from pigs ranging in age from 90 to 400 days. The absolute weights of fat and lean up to 220 days of age were linear for all groups. Restricted energy intake for high-fat lines in both breeds reduced the accumulation of fat but had no influence on lean, while in low-fat lines restriction of energy reduced the deposition of both fat and lean. This indicates that improvement of carcass composition by limited feeding will depend on the genetics of the pigs involved. The average ages at which pounds of fat exceeded pounds of lean in the carcass were as follows: low-fat Yorks at both energy levels, 39 weeks of age; high-fat Yorks and low-fat Durocs on restricted energy, 34 weeks of age; high-fat Yorks and low-fat Durocs on normal energy, 22 weeks of age; and high-fat Durocs on normal energy, 18 weeks of age. Balance trials at 90 days of age showed that pigs on the reduced energy level generally retained more nitrogen per unit of retained energy than pigs on full feed. The high-fat Duroc line was exceptional in that no difference was observed in nitrogen retention between nutrition levels. This line was also lowest in nitrogen retention

(3.73 mg./kcal.) and least efficient in feed utilization (2.79 kg.feed/kg.wt. gain) while the low-fat Durocs had the highest nitrogen retention rate (4.75 mg.N/kcal.) and were most efficient (2.45 kg.feed/kg.wt.gain). The two York lines were intermediate. (AH a3-18)

B. Concentrates - Evaluation and Utilization

Cottonseed meal. Shortly after discontinuance of work on improving the safety and use of cottonseed meal as swine feed (AH a3-16), the Southern Utilization Research and Development Division requested evaluation of cottonseed meals produced by extracting the oil with an azeotrope mixture of solvents, and for help in screening for toxic meals from commercial production. Preliminary pilot studies were done which characterized these new experimental meals as having high nutritional value (equivalent to soybean meal) and very low toxicity, while four of seven commercial meals were identified as toxic. A new project was activated to allow further testing of the azeotrope meals as well as review and testing of detoxification methods. (AH a3-19)

C. Feeding Methods

Limited feeding - gilts and sows. Results of previous studies in which nutrient intake was limited by dilution with high-fiber ingredients showed advantages from restricted diet in terms of superior reproductive performance which were largely nullified by inability to prevent excessive feed wastage. As restricted feeding seemed to offer a better solution to the problem, this work was revised to compare three levels of feed intake during the gestation period. Three levels of the standard Beltsville gestation diet, 6.0, 4.5, and 3.0 pounds per head per day, were fed to gilts in groups throughout gestation. No gilts on the intermediate level (4.5 pounds per head per day) weaned less than seven pigs, while some of those on both the high and low levels lost all their pigs and others weaned only a few. For groups of gilts receiving 6.0, 4.5, and 3.0 pounds of feed per head per day the average number of pigs weaned was 7.25, 9.70, and 6.70, respectively. These results indicate that reproductive performance may be improved by moderate restriction of feed intake during gestation, but either severe restriction or too much feed may be detrimental. This also suggests that individual feeding would be useful to insure proper feed intake by each animal and thus avoid over and under consumption by certain individuals when group feeding is practiced. (AH a2-5)

D. Nutritional Requirements - Trace Mineral Requirements and Interrelationships

1. Dietary zinc increased zinc content of sows' milk. Previous work at Beltsville indicated relatively high zinc content of sows' milk and colostrum in comparison with these secretions from the human, cow, and ewe. Further work in this area included comparison of a standard gestation diet containing 73 or 173 ppm of zinc and a standard lactation diet with 47 or

147 ppm of zinc. Level of zinc was high (97 ppm in fat-free dry matter) in first colostrum regardless of dietary zinc. The zinc content of milk from sows on low zinc diet declined rapidly in the first 24 to 48 hours, then maintained a fairly stable level and averaged at 35 days lactation 59 ppm in fat-free dry matter. Milk from sows on the high level of dietary zinc maintained a level of zinc nearly equal to that in first colostrum and averaged at 35 days lactation 92 ppm in fat-free dry matter. (AH a3-12)

2. Iron content of milk and colostrum of sows. A study of the iron content of sows' colostrum and milk and possible effect of oral supplementation of sows with various iron compounds on level of iron in mammary secretions has been initiated at Beltsville. A control group of 12 sows and a supplemented group of 12 which received the same diet plus 900 mg. of iron as ferrous fumarate/lb. of diet supplied colostrum and milk for assay. On a total dry matter basis, colostrum averaged 6.5 ppm regardless of dietary iron ingested. Mean figures for 35 day milk also based on total dry matter were 4.82 ppm for unsupplemented sows and 8.14 ppm for the supplemented sows. (AH a3-12)

3. Additive effect of calcium and phosphorus on utilization of dietary zinc. Two factorial experiments on interrelations of calcium, phosphorus, and potassium as they affect utilization of zinc were completed with male albino weanling rats. Criteria used were: rate of gain; feed efficiency; zinc content of liver, kidneys, bone, and hair; and serum alkaline phosphatase. Dietary levels of minerals tested were as follows: Ca, 1.2% and .3%; P, 1.2% and .3%; and K, .65% and .1%. No apparent relationship was noted between potassium levels tested and utilization of zinc. The principal conclusion was that high dietary calcium and phosphorus can independently cause a conditioned zinc deficiency and that these effects are additive. (AH a3-12)

E. Management Practices and Equipment

1. Farrowing stalls. Ten different models of commercial farrowing stalls, including two "round" types and one adjustable from rectangular to "diamond" shape are under comparison. Satisfactory results in terms of prevention of mashing losses have been obtained with all models. A basic flaw in design was found in one rectangular stall with sides constructed of vertical bars spaced 7 inches apart. One of the first gilts confined to this crate got her head caught between the bars and required considerable help to get free. Horizontal bars, mesh or closer spacing of vertical bars, would prevent this type of mishap. Aside from safety and convenience of gate latches, bumper guards, etc., the main consideration appears to be cost per litter based on initial cost, maintenance, and durability of the unit. (AH a2-3)

2. Slotted floors for farrowing. Slotted floor units 10 feet by 7 feet were constructed of rough-sawed oak to accommodate two farrowing stalls per unit. Slots were 3/8 inch wide between slats which measured 2 1/8 inches

on top, 1 7/8 inch on the bottom, and 3 inches thick for the front and back of each unit, while three planks 12 inches wide made up the middle section. Pigs farrowed and reared to three weeks of age on these floors were noticeably cleaner than those reared on solid floors with bedding; moreover, no injuries to feet and legs of pigs occurred with 3/8 inch slots. (AH a2-3)

3. Feeding stalls for gilts and sows. In order to equalize feed intake in studies of optimum levels of nutrients required for gestating and lactating swine, individual feeding stalls have been installed and gilts reserved for the breeding herd are being fed at two levels during growth from 150 pounds until bred. Use of these stalls has prevented unequal feed intake and is providing a means for establishing optimum requirements of balanced diets for growth and gestation of gilts and sows. (AH a2-3)

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Nutritional Requirements

- Stevenson, J. W. and Earle, I. P. 1964. Supplementation of sow lactation diets to prevent baby pig anemia. (Abstr.) J. Animal Sci. 23:299. (AH a3-12)
- Stevenson, J. W. and Earle, I. P. 1964. Zinc in sows' colostrum and milk. (Abstr.) J. Animal Sci. 23:300. (AH a3-12)

AREA NO. 19. FUR ANIMAL HUSBANDRY

Problem. Fur animal investigations are needed to obtain fundamental information on methods of increasing the productivity of ranch-raised fur animals, including rabbits. Controlled research is needed on the development of superior lines, or possibly new breeds, for producing higher quality fur and better rabbit meat. The genetics of mutations of mink and foxes and the inheritance of factors for quality of fur and of meat in rabbits require continuous study. Feeding investigations are needed to determine nutritive requirement of various species and the most economical sources of feed to meet their requirements. Of special need is the finding of satisfactory substitutes for expensive raw meat. Low cost byproducts of the meat and fishing industries must be under constant study to develop practical diets. Successful husbandry of these animals requires extensive study of the peculiar characteristics of reproduction and their relation to productivity.

USDA AND COOPERATIVE PROGRAM

This is a continuing program and involves (1) genetic investigations of traits for use in improvement of rabbits, minks, martens, and foxes; (2) research on the reproductive performance of mink, including the effects of hormones and the process of lactation; (3) estimates of genetic parameters and maternal effects concerning economic traits in the production of fryer rabbits; (4) studies with regard to the priming process in fur bearing animals through investigations of the mechanisms involved in the growth of hair follicles (5) research on the basic nutrient requirements and nutrient utilization by mink and the development of diets based on fish, meat and their byproducts for mink, fox, and marten; and (6) the relationship of nutrient factors and physical characteristics of the diet to rabbit production, including the study of various proteins.

The work is in progress at Beltsville, Maryland; Fontana, California; Ithaca, New York; and Petersburg, Alaska. Cooperation is maintained with Swarthmore College and State Experiment Stations of Alaska, California, New York, and Wisconsin. Close cooperation is maintained with the National Board of Fur Farm Organizations.

The Federal scientific effort devoted to the research in this area totals 5.4 professional man-years. Of this number 0.7 are devoted to fur animal breeding, 0.9 to fur animal physiology, 3.6 to fur animal nutrition and management, and 0.2 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

Six state experiment stations, Alaska, California, Florida, Michigan, New York and Oregon are conducting fur animal nutrition research, some of which are in cooperation with the U. S. Department of Agriculture. These studies are primarily concerned with establishment of basic nutrient requirements of rabbits and mink.

The value of antibiotics and antioxidants in mink diets is also being investigated. Consideration is given to development of low cost rations for mink including dry diets. The nature, cause and control of fur abnormalities in mink are being studied. All fur animal breeding research is conducted in cooperation with the U. S. Department of Agriculture.

The total effort on fur animal husbandry at the State Experiment stations is 3.3 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Fur Animal Breeding

1. Breed and strain crossing for production of fryer rabbits. In reciprocal crosses of the U. S. Rabbit Experiment Station New Zealand White strain with three unrelated Californian lines, mortality of live born young from birth to weaning was less for the crossbreds (17%) than for the straightbreds (29%). The proportion of litters with all born dead was greater for crossbreds (14%) than for straightbreds (4%). In an analysis of number born alive, number weaned, and total weaning weight for those litters in which at least one member was born alive, crossbred litters on the average exceeded straightbred litters in each trait in all three crosses. The pooled results of these crosses indicated crossbred superiority of 14% for number born alive; 29% for number weaned, and 25% for total weaning weight. (AH fl-1)

2. Genetic and environmental factors affecting resistance to enteritis in suckling rabbits. The age of the doe, whether or not a rabbit is raised in a foster litter or its own dam's litter, and size of litter, have no apparent bearing on the incidence of enteritis. Season has a very strong effect, there being significantly less enteritis during the warm months than during the colder part of the year. Furthermore, it has been demonstrated that significant regression exists between temperature and the incidence of enteritis. (AH fl-1)

3. Genetics of red cell antigens and serum polymorphisms in rabbits. Results thus far indicate a reasonably normal distribution for J and O substances; however, the inheritance of J-O is not clear. In all but one family where J occurred in the offspring, J was present in at least one of the parents. This one exception, an O x-mating, produced 7 J's and one O. One could postulate a genotype OOII x JOii in the parents to explain

the progeny phenotypes. The dominance relationship of J to O is not clear. JO phenotypes exist yet J x J have produced JO offspring. Thus a genetic system similar to that proposed by Sprague, 1958, is suggested.

Four alkaline phosphatase patterns have been observed in rabbits. Thus far family data have been unable to give a good genetic explanation. (AH fl-1)

4. Genetics and hair characteristics of the "wuzzy" mutation in the domestic rabbit. In the course of crossbreeding experiments a "wuzzy" mutation was produced in one of the lines of California rabbits being used. This mutation resembles that described by Sawin in the Journal of Heredity 50(1): 1959. The "wuzzy" mutation is a recessive defect of the hair characterized by gross matted clumping, ulceration of the eye, and some denudation associated with structural changes in the medulla, cortex, and cuticular scales of the hair. Abnormal secretion from the skin leads to entanglement of hair, irritation of the eye and skin, and an unkempt appearance. (AH fl-1)

5. Genetics of mink. Three blood type systems, designated A, D and E were reported last year: to this can be added a fourth system called G. Some 2,200 mink have been classified as to their blood type in the A system, 810 of these for reaction in the D system, 484 for the two proceeding systems and the E system, and 359 for all four systems. Analysis of pedigrees together with progeny tests indicate that the genes for the specificities at these four loci are on different chromosomes.

The sera of more than 1,500 adult mink from three sources have been examined for normally occurring antibodies, and antibodies against the five blood types A, B, B₂, C and E were detected by the use of saline agglutination tests. "Normal" antibodies were found in several mink sera in the fall following vaccination for virus enteritus. With this exception, antibodies were found only in the sera of females after the pregnancy period, and usually against the blood antigens of the male to which they had been mated. It is suggested that incompatible matings and vaccination for virus enteritus stimulate antibody production, and may account for some of the high mortality of mink kits soon after birth. (AH fl-2)

B. Fur Animal Physiology

1. Seasonal variation in reproductive traits of New Zealand White rabbits. Breeding records collected from 1943 to 1960 were analyzed to ascertain seasonal variation in several reproductive traits of New Zealand White rabbits. There were four months (June, July, August, and September) with average maximum temperatures higher than 80°F. Averages for the traits analyzed were: conception rate, 68%; total litter size at birth, 7.39 rabbits; number born alive per litter, 6.74 rabbits; percent of stillbirths out of total born, 8.85%. Conception rate exhibited a highly significant seasonal trend from a high in the spring to a low in the fall.

Total litter size at birth and number born alive per litter decreased consistently from the spring to a low in September. The monthly proportion of stillbirths in litters with at least one survivor closely paralleled changes in maximum ambient temperature, whereas, the frequency of still-born rabbits in litters without survivors showed no consistent trend with maximum temperature. (AH fl-1)

2. Fetal development and fetal anomalies in rabbits. Fifty-two malformations have been classified thus far on the basis of macroscopic studies and visceral and intracardiac microdissections. Continuing epidemiologic studies of possible genetic, nutritional, viral, toxic, hormonal, seasonal and other factors have not thus far established any etiologic relationship. (AH f2-5)

3. Effect of breeding does at various intervals following kindling on reproductive performance. Work is being conducted to further evaluate the effects of breeding does at short intervals following parturition on the reproductive life of the does, growth of the young, the incidence of enteritis, and total mortality. Two experiments are under way involving breeding intervals of 10-12 days and 24-25 days following parturition. Results thus far indicate that does subjected to these rapid breeding schedules do not perform satisfactorily; their reproductive lives are shortened; they produce fewer litters per doe per year, and mortality among the young rabbits is greater than in litters from does on a standard breeding schedule of from five to six weeks following parturition. (AH fl-6)

4. Reproduction in foxes. Production and fur quality in the small fox herd at Petersburg, Alaska, has increased materially since the antioxidant BHT has been added to their relatively high fish diets. (AH fl-3)

5. Mating systems for martens. Close attention was given to mating of martens at Petersburg, Alaska, during the 1963 breeding season. Fourteen females mated a total of 57 times. This was by far the most active marten breeding season in several years, yet for the second consecutive year and for the third year in the history of the station, no young were born. Occasional checks after observed matings have disclosed live, viable sperm, so it is presumed that fertilization or implantation does not occur due to some nutritional deficiency or management practice. (AH fl-4)

6. Functional role of connective tissue elements in the skin of fur-bearers. In studies at Beltsville, Maryland, of histological sections of the skin of mink and other fur-bearing animals, it was noted that the transformation that takes place in the early pattern of development is influenced by the immediate environment of the follicle and later by other structures which in time become part of the connective tissue surroundings, such as cells of the adipose tissue and the elastic fibers of the dermis.

Small adipose cells appear in the skin of the late fetus and again concurrently with each new hair cycle in the postnatal animal. These cells enlarge and form chains or lobes which later become confluent as the follicles travel upwards in the skin during the priming process. By the time the hairs have reached the resting or "prime" stage, the fat cells appear en masse in the areolar dermis. With each new hair cycle, the story repeats itself and small fat cells are again found between newly developing follicles near the panniculus muscle or limiting layer of the skin.

Elastic fibers in the skin of the fetus, as a general rule, cannot be made visible by staining but are evident because of their refractile nature. As the skin develops, the elastic fibers become more heavily concentrated around the guard hair follicles and send out smaller branches to the nearby follicles of the underfur. Elastic fibers are absent from the hair germs or new hair beds found beneath the club hairs but present a striking appearance in their complete envelopment of the basal end of follicles containing shedding hairs. The elastic tissue framework is an important component of the skin in the regulation of tissue fluid movement and may also aid in the expulsion of the shedding hair. (AH f4-3)

7. Development of a biopsy gun for taking skin samples. A biopsy gun was designed at Beltsville and has been used successfully at Ithaca, New York, for taking skin samples from mink. The method is quick, simple and produces no bleeding, or very little bleeding. No anesthesia is necessary and no clamps or stitches are required. Since the wound is small, there is no damage to the skin, leather, or fur and healing is rapid. No special antiseptic is needed, although a wound dressing spray may be used to cover over the area, if desired. This method does not prove a source of irritation to the animal and in no way curtails the animal's activities. A plunger constructed in the gun is used to eject the biopsy from the recess in the cutting die and the skin sample is placed directly into the fixative.

There is no need for flattening the skin section because of its small size. The inside diameter of the punch is only about 7/32" and no curling of the skin has been experienced. The histological sections obtained have all been excellent. (AH f4-3)

C. Fur Animal Nutrition and Management

1. Development of mink diets based on sea fish and sea mammals. Many of the inexpensive fish products available for fur animal feed in Alaska are high in unsaturated fatty acids, oxidize rapidly, and when fed at levels of 30% or more result in poor health and losses from steatitis. Antioxidants or alpha-tocopherol protect these fish rations from this malady but to date results have been conflicting where heads from different species of salmon were fed.

Diets containing 50% pink salmon heads or 50% chum salmon heads, with and without alpha-tocopherol or the antioxidant, BHT, or 15 and 25% fur seal meat were compared. Production results varied considerably with one control ration (pink salmon heads), one BHT ration (chum salmon heads), and one seal meat ration (25%) having excellent production and the other five falling below that normally expected, indicating possible influence from factors other than the additives being tested. The two diets containing BHT averaged slightly better production than those receiving the alpha-tocopherol or seal meat.

Kits from each of the all-fish lots, carried through the summer and fall until pelting in December, had a higher incidence of steatitis on the rations containing pink salmon heads than those containing the same amount of chum salmon heads. BHT and alpha-tocopherol adequately protected the rations containing these products. Animals on the ration containing pink salmon heads supplemented with alpha-tocopherol maintained the best general health, produced the best quality fur, and had the highest pelt value. (AH f3-1)

2. Feeding of fresh water scrap fish to mink. Two species that are abundant are the alewife and the Great Lakes trawler chub. During the reproductive cycle, canned alewives at a 30% level were fed to 20 female mink and their progeny. Reproduction was excellent when compared to mink receiving a control ranch diet (4.20 vs. 3.20 kits per female kept at 42 days of age). Work is being continued on a commercial cooked alewife product and an experimental alewife press-cake during the 1964 kit growing season.

During the summer and fall of 1963, trawler chubs were fed to mink at a 30% level. The growth gains of these mink were less when compared to kits receiving a control ration (910 vs. 1084 grams). The comparable quality of the fur is currently being evaluated.

Feeding of trawler chubs to mink gave very poor reproduction and the kits were considerably smaller than those of the control diet. (AH f3-1)

3. Use of iron compound to prevent cotton pelts. Cotton pelts are a result of an anemic condition which renders otherwise normal mink pelts nearly valueless. Four equal groups of 88 dark and mutation young mink were fed the same diet plus 0, 200 mg., 400 mg., and 800 mg. per pound, respectively, of a new iron compound during their growing and furring-out period from July 18 until December 5. This product was definitely advantageous in minimizing and/or preventing the "cotton" pelt condition and helped promote better general health. (AH f3-1)

4. Effect of nitrogen fertilizer on the nutritive quality of Bermuda grass. Investigations have been initiated to provide evidence as to the sensitivity of rabbits for testing forage of varying quality, to provide basic information on the nutritive quality of Bermuda grass as rabbit feed, and to determine the effect of various C/N ratios on the performance of growing rabbits, relating this to the management of the pasture. (AH f3-2)

5. Studies of protein in rabbit feeds. To critically evaluate the National Research Council recommendations for protein requirements in the rabbit diet, and to obtain further information on protein requirements for fryer production, an experiment utilized five levels of crude protein. Analyses of samples taken from the various feeds showed actual crude protein levels of 17.0, 17.5, 18.2, 19.4, and 20.8%. There was little, if any, advantage to feeding diets containing more than 17% crude protein in the production of fryer rabbits. In fact, the results indicated that fryer rabbits raised on the lowest protein level had comparable weaned weights and feed conversions, and lower mortality, than those raised on the diets containing the highest level of protein. These results are in line with recent recommendations by the National Research Council. (AH f3-4)

6. Pantothenic acid requirements of growing mink. The minimum pantothenic requirement of mink kits for growth was found to be 5 mg. of calcium pantothenate/kg. of diet while 8 mg/kg. of diet was required for optimum performance.

Early effects of hypovitaminosis were anorexia and reduced serum cholesterol. The gross pathological lesions terminally were diarrhea, cachexia, emaciation, and dehydration with hemorrhagic gastric ulcers. Histological evidence of deficiency was epithelial changes in the skin, and changes in the digestive, respiratory and urinary systems which included loss of cell integrity and reduced cell proliferation. There was also a mild neuron degeneration. (AH f3-5)

7. Development of purified diets for mink. Purified diets have been developed for mink which are adequate for nutritional studies during growth, however, they do not give optimal growth and they are entirely inadequate during the reproductive cycle. Research was conducted to re-evaluate the vitamin and mineral composition of the currently used purified diet in light of the known nutrient requirements of the mink.

Levels of most of the B vitamins were considered adequate but were increased in the new diet to account for possible destruction. Vitamin C was added to the new diet and the level of vitamin E was increased. The mineral mixture was altered to take out a component known to cause B vitamin inactivation and the levels of copper and zinc were increased in line with known requirements of other species.

Weight gains of mink receiving both the old and the new diet were good, the males achieved an average weight of 1700 grams and the females 800 grams.

These weights compare favorably with those of ranch mink at a comparable age. There was no significant difference in the weight gains or feed efficiency of the mink receiving the two purified diets. On all experiments conducted at Ithaca where mink have been fed purified diets, there has been a low incidence of mink showing a common syndrome of either chronic or acute anorexia accompanied by fatty liver degeneration, hemorrhagic gastritis (fundus and pylorus) and duodenal enteritis with some myocardial lesions. Infectious disease is not indicated. Further work is currently being conducted to attempt to determine the cause of this syndrome. (AH f3-5)

8. Development of practical diets for mink. Fresh liver is considered to be an essential dietary ingredient to mink during the reproductive cycle. Control mink receiving 5% liver produced 3.2 kits per female kept at 42 days of age which weighed an average of 320 grams. Mothers receiving 2-1/2% liver produced an average of 3.0 kits which weighed an average of 320 grams. Those mothers that received no fresh liver only produced an average of 1.9 kits per female and the kits weighed an average of 270 grams. Blood hematocrit, hemoglobin, or differential white blood cell counts did not demonstrate differences that could be attributed to the diets. This and other evidence points to the possibility of unidentified nutrient(s) required for mink during reproduction. (AH f3-6)

9. Effect of feeding thyroid-active ingredients on reproduction of mink. Recent field observations and studies with rats suggest that one cause of reproductive failures in mink during the past few years has been the feeding of ingredients containing high levels of naturally occurring thyroid-active compounds. Mink may receive the thyroid-active principle or compound through the feeding of gullet trimmings, a packing house by-product. It is also possible that the thyroid-active material is obtained by feeding calf heads or lungs which have the trachea attached.

Studies conducted in 1963 showed that gullet trimmings fed at a 15% level or their equivalent of thyroid activity in the form of tri-iodothyronine and sodium-L-thyroxine caused reproductive failures due to resorption of the kits and poor milk production by the mothers.

Studies conducted in 1964 confirmed the 1963 results and demonstrated that a level of the purified thyroid compounds equivalent to 7-1/2% gullet trimmings also gave poor reproduction performance. (AH f3-6)

PUBLICATIONS -- USDA AND COOPERATIVE RESEARCH

Fur Animal Breeding

- Rollins, W. C., Casady, R. B., Sittmann, K., and Sittmann, D. B.
1963. Genetic variance component analysis of litter size and weaning weight of New Zealand White rabbits. J. Anim. Sci., 22(3): p. 654-657. (AH f1-1)
- Shackelford, R. M. 1963. Types of mink (Section 1). Blue Book of Fur Farming. (AH f1-2)
- Shackelford, R. M. and Hartsough, G. R. 1963. Breeding - Section IV. The Blue Book of Fur Farming. (AH f1-2)
- Shackelford, R. M. 1964. Immunogenetics and Neonatal Deaths in the Mink. Kellogg symposium at Battle Creek, Michigan. (AH f1-2)

Fur Animal Physiology

- Baird, B. W., Adey, W. R., Baird, C. D. C., Casady, R. B., and Hagen, Jr., K. W. 1964. Congenital malformations of unknown etiology in domestic rabbits. Anat. Rec 148(2): p. 257 (Abstract). (AH f2-5)
- Dolnick, E. H., Cabell, C. A., Robbins, J. D., and Oltjen, R. R. 1963. Hair growth pattern in the rat as influenced by diets low in potassium. Proc. XVI International Congress of Zoology, 2, p. 44 (Abstract). (AH f4-3)

Fur Animal Nutrition and Management

- Casady, R. B., Hagen, Jr., K. W., and Sittmann K. 1963. Effect of antibiotics on growth and enteritis in rabbits. J. Anim. Sci. 22(3): p. 833 (Abstract). (AH f3-2)
- Casady, R. B. 1963. Success in feeding domestic rabbits. All Pets Magazine 34(9): p. 22, 44, and 45. (AH f3-2)
- Casady, R. B., Mize, K. E., and Suitor, A. E. 1963. Enteritis and growth in rabbits as affected by water intake. National Rabbit Raiser 31(1): p. 7 and 19, and other rabbit journals. (AH f3-2)
- Casady, R. B. Hagen, Jr., K. W., and Sittmann, K. 1963. Aureomycin and terramycin supplements in rabbit rations. Small Stock Magazine 47(10): p. 10 and 18. (AH f3-2)
- Casady, R. B. 1963. The effect of restricted availability of water on the incidence of enteritis and on growth in young rabbits. Laboratory Animal Care 13(5): p. 685-688. (AH f3-2)

- Casady, R. B., Hagen, Jr., K. W., Bertrand, J. E., and Thomas, H. G.
1964. Effect of zinc bacitracin on the incidence of enteritis and growth
in young rabbits. Clinical Medicine 71(5): p. 871-875. (AH f3-2)
- Casady, R. B., Hagen, Jr., K. W., and Sittmann, K. 1964. Effects of high
level antibiotic supplementation in the ration on growth and enteritis
in young rabbits. J. Anim. Sci. 23(2): p. 477-480. (AH f3-2)
- Travis, Hugh F. 1963. Some considerations in the formulation of mink
rations. Proceedings of 1963 Cornell Nutrition Conference for Feed
Manufacturers. pp. 122-126. (AH f3-6)
- Travis, Hugh F., Bassett, Charles F. and Warner, Richard G. 1964.
Gullet trimmings can be disastrous to reproduction. American Fur
Breeder 37(2): p. 14, 34. (AH f3-6)

AREA NO. 20. ANIMAL PERFORMANCE AND MANAGEMENT RECORDS

Problem. Livestock and poultry improvement cannot be accomplished effectively without adequate records of performance and management. Furthermore, records which have widespread utility must be produced through carefully coordinated programs in order that uniformity may be obtained in measurements and analytical procedures. Continual revision of record procurement and evaluation techniques in accordance with current research findings requires integration of program operations and research. Only in this way can there be a continual chain of discovery, application, and field testing.

USDA AND COOPERATIVE PROGRAM

This is a continuing long-term program of performance testing dairy cattle and poultry, including the evaluation of the genetic merit of dairy cows, sires and herds, chickens for egg or meat production, and turkeys. Also included in the program is the control of hatchery disseminated poultry diseases. The work on dairy cattle performance testing is cooperative with 50 States and Puerto Rico and the Records and Breeding Committees of the American Dairy Science Association. Cooperation is also carried out with the National Association of Artificial Breeders and the various dairy cattle breed registry organizations. The poultry work is cooperative with Official State Agencies in 47 States and with the supervisors of 23 random sample tests in the United States and Canada.

The Federal scientific effort devoted to the programs in this area totals 6.5 professional man-years. Of this number, dairy cattle work accounts for 3.3, 3.0 devoted to performance testing and 0.3 to program leadership, and poultry work accounts for 3.2, 3.0 devoted to performance testing, and 0.2 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The effort of the State stations in this area is quite large. It is difficult, however, to make a manpower estimate which would be distinct from that in breeding sections. As the USDA material indicates, much of the effort in DHIA and in poultry testing is cooperative with the States. At several State stations, DHIA records are processed for dairymen on a reimbursable basis. Data derived is used in estimation of genetic parameters, etc., by resident investigators. Similarly, the random sample poultry tests on broiler and egg production strains conducted at State locations provide information on performance and mortality of commercial stocks. Eggs and meat from these poultry tests are used in detailed studies such as strain comparison of chemical constituents and correlation of these items with production traits.

Animal performance and management records with beef cattle, swine, and sheep are frequently obtained through cooperation with producers, extension service, and industry. In several States, swine testing stations have been established and operated on a self-sufficient basis supported by fees. Research personnel often act in an advisory capacity. In many States, programs of on-the-farm performance and progeny testing of beef cattle have been developed. Again, research and extension people frequently cooperate in this endeavor. At central facilities in some States, bulls belonging to producers are tested for growth and feed efficiency often under the direction of research personnel. Similarly, a limited number of ram testing stations have been developed for indicating growth rate.

No estimate of State station professional man-years is made.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Dairy Cattle

1. Sire evaluation program. Using 1,911,102 records of performance which were reported during the year, along with the total of 10 million records available in magnetic tape files, 22,313 genetic appraisals of sires were made and the industry was provided 66,383 individual sire records. These genetic appraisals were made on a quarterly basis and included all sires qualifying with five or more progeny having herdmates. A total of 1,338,130 progeny were included in the genetic appraisals. (AH i4-1)

2. Cow evaluation program. Genetic appraisals of dairy cows were performed initially during the year and according to the index,

$$I = b_1(C - H_c) + b_2(S - H_s),$$

where b_1 is the appropriate weight for the cow, C is the cow's average performance, H_c is the adjusted average of the cow's herdmates, b_2 is the appropriate weight for the sire, S is the average of the sire's paternal half sibs, and H_s is the adjusted average of the herdmates of the paternal half sibs. This indexing procedure was developed and implemented in order to provide the industry with reliable estimates of breeding value of the cows enrolled in dairy recordkeeping. Approximately 500,000 cows, which represent registered progeny of AI bulls, were appraised and the top 2% appropriately identified for use by the industry. (AH i4-1)

3. Dairy recordkeeping programs. The 1,420 dairy herd improvement associations employing 2,474 supervisors provide the organizational machinery for operating the program in the 50 cooperating States. Participation in the National Cooperative Dairy Herd Improvement Program continued to expand and was as follows:

<u>Plans</u>	<u>Herds</u>	<u>Cows</u>
Standard DHIA	40,670	2,010,144
Owner-Sampler	25,598	752,229
Weigh-a-Day-a-Month	<u>1,396</u>	<u>60,149</u>
Total	67,664	2,822,522

A total of 1,911,102 records of performance were reported to the Dairy Cattle Research Branch for use in genetic appraisal evaluations and research.

The artificial insemination program, through which the superior sires developed and recognized in DHIA herds are utilized, bred a total of 7,438,293 dairy and 235,289 beef cows. This represents 41.2% of the nation's dairy cows of breeding age. (AH i4-2)

4. DHIA record analysis and research

(a) Recordkeeping statistics. Cows in standard DHIA herds produced 11,286 pounds of milk and 434 pounds of fat in 1962-63, and exceeded cows not enrolled in recordkeeping by 4,136 pounds of milk. Cows were fed an average of 3,900 pounds of concentrates, produced a product valued at \$495, and returned to the farmer an income over feed cost of \$277 per cow. (AH i4-3)

(b) Regression of a sire's breeding value. Theoretical regressions of the breeding value of sires on daughter average, average deviations from herdmates, and adjusted daughter averages were derived. It was concluded that adjustment for variation in the number of herdmates is necessary and that use of the adjusted herdmate average, as currently performed in the USDA sire evaluation program, achieves this end. (AH i4-3)

(c) Biases in adjustment factors for age. Gross and paired methods were used to compute age conversion factors for each of four geographic regions of the United States. Only one region (Western Midwest) showed a serious discrepancy between the two sets of factors. (AH i4-3)

(d) Value of information on mates of sires in artificial insemination (AI). Estimates of breeding value of 207 AI sires were compared, based on daughter deviations and daughter deviations plus dam deviations. The rank correlation between the two estimates was +0.998, indicating that information from dams does not increase the accuracy of sire evaluations. Heritability estimate for milk yield, based on daughter-dam regression, was 0.24. (AH i4-3)

B. Poultry

1. National Poultry and Turkey Improvement Plans. During 1963-64, a total of 35.8 million chicken breeding birds in 18.5 thousand flocks and

3.7 million turkey breeding birds in 2.1 thousand flocks were blood-tested and found negative for pullorum and typhoid. These birds produced hatching eggs for 1,979 hatcheries with a hatching capacity of 390 million eggs. In addition to participating in the disease control phase of the Plans, over 38 million chickens and turkeys were in flocks qualified for a breeding classification.

The number of pullorum and typhoid reactors found during the initial blood-testing of breeding stock showed a slight increase over last year. Percentagewise, it rose from .0049 to .0054. With this low rate of infection, it may be expected that these year-to-year variations will occur. With the increasing emphasis on field investigations of all laboratory diagnoses of pullorum and typhoid, it is anticipated that the foci of the infections will be located more quickly and eliminated as potential disseminators of these two diseases.

Although the rate of infection of pullorum and typhoid in breeding flocks has remained at a low level for the past five years, the rate of infection of other paratyphoids has steadily increased. Recognizing this problem, the turkey delegates to the 1964 National Plans Conference voted to include a typhimurium control program in the National Turkey Improvement Plan. These same delegates also recommended a *Mycoplasma gallisepticum* (PPL0) control program as a voluntary part of the Turkey Plan.

For the first time in the history of the National Turkey Improvement Plan, the number of Bronze turkey breeders tested has fallen below 50% of the total number tested.

Reports of exports by Plan participants show that over 92 million units (chicks, poults, and hatching eggs) were shipped to foreign countries during 1963. This represented an increase of 19 million units or 26% over the 1962 exports. A special listing of stocks available for export was published as an aid to the development of international distribution by breeders in the United States. These lists were distributed to prospective purchasers by the United States Agricultural Attache in various countries.

2. Random sample performance tests. The data obtained from random sample production tests have generally been received by the poultry industry as a reliable source of information. When these data are treated by acceptable statistical procedures to minimize non-genetic differences, and then combined by stocks over tests and over years, the information becomes even more reliable as a stock selection guide for commercial poultrymen.

The Poultry Improvement staff collected data from 15 United States and four Canadian random sample egg laying tests in 1963. This information covered the performance of more than 52,000 birds tested in 1,305 pens. Sixteen traits of economic importance were evaluated for the 167 different stocks that were tested.

In 1963, for the first time, the combined analysis was computed from the data obtained over a two-year period, as compared to the single year's data in the past. This procedure permits even more reliable predictions of the performance of the stocks. The analysis took into account the repeatability of stock performance within years and between years as well as the correlation among replicates within a test and within tests over years. The number of tests in which a stock is entered, the environmental or non-genetic differences, and the level of the performance of a stock in relation to other stocks in the same test were also used in the analysis. The results of these computations, expressed as regressed means with 80% confidence limits, are predictions of what the performance of a stock would have been if the stock had been tested at 52 locations over the two-year period.

Performance records made by 3,800 turkeys, representing 34 entries of 23 different stocks, were collected from four random sample turkey meat production tests. The data were analyzed separately by tests, and Duncan's multiple range test was applied to 12 traits to show the statistical significance of differences between entries within a test. The figures were further analyzed by combining the performance of the stocks across tests and computing the regressed mean and LSD range for each of 15 traits for each stock. All turkey test data were published under one cover and distributed to the turkey producers upon request.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Dairy Cattle

DHIA Sire Summary List. Sept. 1963. ARS-44-132, 364 pp.; Nov. 1963. ARS-44-135, 218 pp.; April 1964. ARS-44-140, 509 pp.; June 1964. ARS-44-145, 153 pp.

DHIA Cow Index List. April 1964. ARS-44-139, 84 pp.

DHIA Cow Performance Index List. June 1964. ARS-44-146, 160 pp.

DHIA Lactation Averages. May 1964. ARS-44-143, 121 pp.

Dairy Herd Improvement Letters. 1963. ARS-44-131, 134, and 136; 1964. ARS-44-137, 138, 141, 144, and 147.

Miller, R. H. 1964. Regression of a sire's breeding value on various functions of daughters' and herdmate production. J. Dairy Sci. 47:305.

Poultry

Breed Distribution of NPIP Participating Flocks by States and Divisions. 1951-52, 1961-62, and 1962-63. ARS 44-2.

Tables on Hatchery and Flock Participation in the National Poultry Improvement Plan by States and Divisions. 1961-62 and 1962-63 and U. S. Summary, 1957-58 to date. ARS 44-3.

Tables on Hatchery and Flock Participation in the National Turkey Improvement Plan by States and Divisions. 1961-62 and 1962-63 and U. S. Summary, 1957-58 to date. ARS 44-4.

Hatcheries and Dealers Participating in the National Poultry Improvement Plan. ARS 44-6.

Annual ROP and Performance Test Summary 1962-63. ARS 44-7.

Participants in the National Turkey Improvement Plan. ARS 44-8.

Turkeys in NTIP Flocks and Their Distribution by States and Varieties, 1951-52, 1961-62, and 1962-63. ARS 44-11.

Turkey Performance Tests. 1963. ARS 44-13.

1963 Report of Egg Production Tests, United States and Canada. ARS 44-79-4.

NPIP and NTIP Official State Agencies. CA-44-7.

Poultry Stocks Available for Export by Breeders or Their Agents in the United States. CA-44-51.

Proposed Changes in The National Poultry Improvement Plan and The National Turkey Improvement Plan.

AREA NO. 21: PRODUCTION INFLUENCES ON ANIMAL PRODUCTS

Problem. Beef, lamb, pork, and poultry are excellent sources of wholesome and digestible animal proteins and fatty acids necessary in maintaining a healthy, appetizing diet. However, these meats must be of high quality, as well as in plentiful supply, if they are to retain their high position and esteem in the minds of consumers. Proper finish, a high proportion of lean, with adequate intramuscular fat, tenderness, full flavor, and color desired by the consumer are the goals the meat producer must strive to attain through breeding, feeding, and management. The quality of cuts and kind of meat are directly reflected in the demand and in the price of the product.

Egg shell strength and yolk quality, strength of wool, fatness, quantity, flavor, color, and tenderness of meat are all known to be influenced by production practices. However, these quality characteristics and many more are not well understood, even though they are of considerable economic importance. Effective measures of evaluating quality differences are of great importance in determining the nature and effect of production practices on the products.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will be useful in aiding and directing livestock production. Research on beef, veal, lamb, and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality and quantity. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. Research on humane slaughter was continued on a reduced scale, primarily to bring to a conclusion some phases of electrical immobilization and physiological responses. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; and in cooperation with eight State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and Development Divisions, the Human Nutrition Research Division, the Agricultural Engineering Research Division, and the Market Quality Research Division.

The Federal scientific effort devoted to research in this area totals 15.6 professional man-years. Of this number 5.5 are devoted to beef; 1.1 to lamb, mutton, and chevon; 4.0 to pork; 1.0 to poultry and eggs; 2.1 to wool, fur, and fiber; 0.5 to humane slaughter; and 1.4 to program leadership.

A grant with the Polish Academy of Sciences in Poland provides for studies on the color of pork as influenced by heredity, sex, age, feeding, and management. Its duration is for five years (1960-1964) and involves PL 480 funds with \$42,784 equivalent in Polish zlotys.

PROGRAM OF STATE EXPERIMENT STATIONS

Beef. The influence of feeding and management treatments on carcass and meat characteristics include fattening on grass, drylot, or combinations of these; varying the length of heavy silage feeding preceding finishing with a high-energy ration; creep feeding versus no creep feeding during the nursing period, and various combinations of ration ingredients with and without adjuvants. Many of the projects include economic considerations as well as consumer acceptance and laboratory analysis for quality. Regional project NC-58 is designed to objectively identify the factors that characterize differences in beef carcasses, evaluate the relative importance of these factors and find the best indicators of these carcass traits in the live animal.

A number of breeding projects contributing to regional research projects NC-1, W-1, and S-10 are designed to determine the effectiveness of selection in improving carcass traits. Other independent studies include the importance of beef conformation as contrasted with dairy type in the production of consumer acceptable beef.

Lamb, Mutton, and Chevon. A limited amount of research is concerned directly with the influence of nutrition and management on quality of lamb produced, but a concerted effort is being made in the western region under W-61 to define and measure carcass quality and to determine the effectiveness of selection for muscular development. Several stations are studying the pattern of growth in different breeds and crosses as affected by feed, sex, and type of birth.

Pork. A majority of projects discussed in the Nutrition and Management and Breeding problem areas include appraisal of the end product--the carcass. Research at some stations, however, has as its primary objective the influence of varying ratios of protein to energy and total feed consumption on carcass characteristics, and an evaluation of various criteria of selection for superior meat-type swine.

Poultry and Eggs. Research on egg quality includes work on the causes and prevention of blood and meat spots and undesirable yolk coloration. Egg shell quality must be good in order to maintain high interior quality in

market channels, and the effects of nutrition, heredity, and environment on egg shells are being investigated. The effects of different egg washing techniques on interior quality are also being evaluated. Research is underway on the effect of nutrition and management on chicken and turkey carcass quality traits such as skin pigmentation and a desirable amount of fat.

The total State scientific effort devoted to production influences on animal products research is 51.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Beef

1. Tenderness. Biopsy samples were surgically removed from the right side of 35 six-month-old calves, 32 nine-month-old calves, and 39 twelve-month-old steers, and refrigerated 48 hours. Muscle tissue was heated to doneness in deep fat and tested with the slice tenderness evaluator (STE) for tenderness. A low relationship was noted between the STE shear values of the biopsy samples and those of the 9-11 rib roasts from the carcasses of the mature animals. Ninety-one percent of the biopsy samples had STE shear values higher than those of the matching roasts or 19.0 and 11.8 pounds, respectively. Part of this difference may have been influenced by the animal's later nutritional regimes and greater degree of finish. (AH d4-4)

Continued study of refinements in methodology and usefulness of the STE as an objective tenderness testing method indicated that the meat slice need not be held in position by the holder place. Operating time was reduced one-third by eliminating use of the holder. Under present operating procedures, the STE measurement efficiency and accuracy compare favorably with the Warner-Bratzler shear. Correlations between STE shear values and panel tenderness score usually range from $-.74$ to $-.85$ for beef samples. (AH d4-4)

In a study of beef roast slices from the heated 9-11 rib roast from 136 beef carcasses, it was found that the three dorsal locations of the muscle cross-section were the most tender; while the medial and lateral locations were 5% tougher. The variance between locations of the muscle cross-section strongly emphasizes the need for careful selection and control of sampling when testing for tenderness. (AH d4-4)

Steak and 9-11 rib roast samples from 59 steer and cow carcasses, grading Choice + to Utility - and maturity groups ranging from A+ through F (15 to 80 months of age) have been tested by a palatability panel. Certain animals appeared to have more palatable roasts than steaks, but in others the reverse was true. These irregularities occurred more frequently among carcasses of the older maturity groups. The samples from the younger beef carcasses (maturity group A+ through B+) showed no difference in average palatability scores between roasts and steaks. (MQ 3-34)

In a study to determine specific palatability characteristics of beef samples, 48 loin and 9-11 rib samples were tested from 48 beef carcasses representing Shorthorn, Angus, and Hereford steers produced at the Beef Cattle Research Station, Front Royal, Virginia. The results indicated that loin samples (one-inch steaks) from Herefords had a more pronounced and desirable lean meat flavor than samples from the Shorthorn steer carcasses. Samples from the Angus and Hereford steer carcasses had a finer texture, were more tender, had a richer and greater quantity of juice and a higher overall desirability among their steaks than loin samples representing the Shorthorn breed. As in previous reports, the Shorthorn steers had the less tender meat. (AH d4-4 and MQ 3-34)

An analysis of the data obtained from the study of paper chromatographic separation of the tissue free-amino acids and their relationship to tenderness of beef muscle was made. The statistical conclusions were that a relationship does exist between meat tenderness and the amino acids represented by leucine-isoleucine. However, the relationship is not sufficiently high to warrant its exclusive use as an objective method for evaluating tenderness. It was useful in differentiating between rations. (AH d4-6)

A comprehensive statistical analysis of the data on 112 beef samples on free amino acids (leucine-isoleucine), hydroxyproline, the Warner-Bratzler shear, and the palatability committee shows that each measures differences in tenderness. The Warner-Bratzler shear accounted for 62% of the variation in panel tenderness and was the only objective measure significantly related to panel tenderness in rib samples from six-month-old animals. However, on those samples tested from beef after reaching slaughter weight, all three measures were significantly related to tenderness. The Warner-Bratzler, hydroxyproline, and leucine-isoleucine methods accounted for 22, 33, and 5% of the variance in panel tenderness, respectively. (AH d4-6)

Analysis of composite samples from 10 animals in which steaks from two muscles, longissimus dorsi and biceps femoris, were cooked to final temperatures (61, 68, 74, and 80° C), indicate a step-wise decrease of collagen nitrogen at each increased temperature. The percentages of decrease are similar for the two muscles. An initial study on the effect of steak size on cooking time to 80° C on shear value and on the bound water was completed. Small steak samples were cut to $1\frac{1}{2}$ x 2 x 1 inch in size and weighed approximately 90 grams. Cooking times were reduced 17 and 20% and shear values were reduced 11 and 13% for the L. dorsi and B. femoris, respectively. It would appear that shear values are dependent upon cooking time as well as final temperature. The correlations between shear values for the larger (normal cut) vs. the smaller steaks was 0.87 for L. dorsi and 0.68 for the B. femoris. The correlations between cooking times for the two sizes of steaks was low. This would seem to indicate that animal variation was not a factor that influenced cooking time. (AH d4-5(c))

2. Composition. A majority of the ultrasonic research information on live cattle fatness and muscling has been obtained from measurements over the back and rib of the animal. Recent findings reported by this and other laboratories suggest that rib-eye area is not a good measure of total muscling of the animal. For this reason, efforts have been directed toward determining measurement areas capable of yielding more meaningful ultrasonic values of fatness and particularly muscling. (AH d4-7 and MQ 3-34)

The study undertaken last year to more effectively and accurately estimate live animal composition from linear measurements of the chilled carcass was expanded and continued. The volume of the total carcass, hindquarter (round + rump + loin), and the dorsal wholesale cuts (hindquarter + prime rib + chuck) were computed from five measurements, utilizing the basic definition of a triangular pyramid. Correlations between the calculated volumes for the three partitioned areas and the corresponding weights of the cuts were 0.78 or above. Carcass and round volume accounted for 90% of the variance in muscle and fat as determined by principal component analysis. This study is being continued and extended to include the live animal. (AH d4-7)

3. Quality and quantity of meat as affected by production

(a) Effect of sex. The data from yearling Hereford bulls and steers indicate that roast meat samples from bulls were substantially less tender, less juicy, lacking in flavor of lean, and from the color of lean less done than similar samples from steer beef when heated to the same degree of doneness. Part of these differences could be attributed to the differences in finish. Ether extract fat in the eye muscle of the 9-10-11 rib indicated that considerable variation existed in intramuscular fat when certain lines were crossed. The cross-line bull rib samples had more ether extract fat than representatives of either parent line. The data are being further examined for heterosis effects. (AH d4-7)

A preliminary analysis of data from an experiment comparing eating quality characteristics of bull and steer carcasses from identical twins indicated that steer carcasses contained more ether extract fat in the eye muscle, had a higher marbling grade, were more tender, and the overall desirability of the meat was much better. (AH d4-7)

(b) Beef from beef, dual-purpose, and dairy type steers. Holstein steers had the largest rib eyes (11.4 sq. in.) and the Jersey the smallest (8.9 sq. in.). However, when expressed in inches per hundred pounds carcass weight, the breeds representing the three types ranked as follows: Angus, Holstein, Jersey, and dual-purpose Shorthorn with values of 1.95, 1.82, 1.75, and 1.61 square inches, respectively. Feeding only hay to a portion of the steers resulted in less marbling of the loin eye and in a smaller total rib-eye area. However, expressed as area/cwt. carcass, the values were 1.88 inches compared with 1.80 for the other two rations. A

ratio of lean meat to bone showed the Hereford steers to have the largest ratio, 3.69:1; followed by dual-purpose Shorthorns and Angus 3.60:1; Holsteins 2.97:1; and Jerseys 2.84:1. Beef-type steers had more extensive marbling deposits in the lean than did animals of the other types and higher slaughter and carcass grades. The palatability panel noted no breed differences in the 9-11 rib roast sample in desirability of aroma, but the flavor of lean for the Angus was one-half panel-unit higher than for the Jersey. No significant palatability differences were noted among 9-11 rib roast samples for the non-beef type steers for tenderness, juiciness, and overall desirability. Beef type steers rated slightly higher in these three categories than non-beef type steers. There were continued significant differences in eating quality of 9-11 rib roast samples from calves fed milk and calves fed milk replacer. Samples from calves fed milk were significantly more tender at six months of age than those fed replacer. However, when similar calves were fed to slaughter weight on concentrates or hay, they had recovered from any deleterious effects due to feeding the first six months on milk replacer. (AH d3-6)

(c) Electrical properties and quality of meat. A study was made to investigate the direct current electrical properties of fresh beef muscle at 3/4, 24, 48, 72, and 144 hours post-mortem. In addition to the usual electrical measurements of microamperage, millivoltage, and resistance, a technique was developed to measure the ability of the fresh tissue to retain an induced voltage. Data taken on 10 calves and 61 mature cattle indicated that tissue microamperage and voltage decreased sharply between 45 minutes and 48 hours post-mortem; while resistance and time-voltage measurements increased rapidly during the first 24 hours. When electrical properties were compared with palatability scores of the meat given by the panel, it was found that time-voltage values were significantly related to the overall desirability scores and tenderness values among calves and also to the juiciness scores among mature beef. Electrical resistance values were significantly related to one or more tenderness measures in calves and mature beef. Lower time-voltage curves and resistance values were associated with more tender and juicy meat.

B. Lamb

1. Tenderness and palatability. Data obtained on 49 lamb legs that were tested for palatability and objective tenderness showed pronounced variability in tenderness, particularly the Warner-Bratzler shear values. These values ranged from 8.0 pounds to 36.2 pounds and had a standard deviation of ± 5.97 pounds. The wide range of values in palatability scores for tenderness, juiciness, and overall desirability resulted in large standard deviations and coefficients of variability; the latter were 21.2%, 23.3%, and 28.1%, respectively. The Warner-Bratzler shear values had a coefficient of variability of 29.3%. (AH b6-1)

A statistical analysis of the palatability data from lambs used in a four-way crossing experiment over a period of 12 years and involving 724 lambs was completed. The results show a distinct trend in tenderness and flavor of lean due to crossbreeding. Also, with an increase in desirability of fat flavor, there was an increase in desirability of flavor of lean. The results show that crossbreeding may be used to increase the palatability characteristics of lambs when Southdown, Shropshire, Hampshire, and Merino foundation stocks are used. (AH b6-1)

2. Composition. The fat and lean depth at the last rib was ultrasonically measured on 148 lambs during the two-year period. Comparison of these data with actual tissue thicknesses obtained from the carcass was accomplished using a correlation matrix analysis. Ultrasonic values made one inch off the midline correlated 0.55 with actual depth, loin-eye thickness, and covering fat. However, a similar correlation made for values obtained two inches off the midline was only 0.41. The latter value, although significant, suggests that more reliable estimates of tissue quantity are obtainable closer to the animal's midline. Among these lambs, the ultrasonic measurement made one inch off the midline of the live animal accounted for 66% of the total variation in the longissimus dorsi thickness as measured in the carcass. The two ultrasonic measurements accounted for 86% of the total variation in the longissimus dorsi thickness. (AH d6-1 and MQ 3-34)

3. Carcass evaluation. Statistical analysis of lamb carcass data from over 1100 lambs used in crossbreeding studies showed that differences in year of birth were significant for all factors studied; ewe lambs were characteristically fatter than ram lambs, and there were definite advantages in both quantity and quality of lambs due to crossbreeding. A composite evaluation of crossbreeding effects indicated significant changes due to crossbreeding for all of the factors studied singly. A study of the interrelationships of selected factors indicated that most of the quantity factors were independent of quality factors among the crosses studied. This indicated that a sound crossbreeding program could be developed to improve both quantity and quality attributes in lambs without incurring any detrimental correlated responses. Carcass weight, average body width, plumpness of leg index, and fat thickness over the longissimus dorsi were the most useful carcass factors studied to predict quantity factors. The Warner-Bratzler shear and intensity of flavor of lean of roasted leg were the most useful factors to predict quality factors. (AH b6-1)

4. Breeding as it affects carcass quality. Publication of results from the Western Regional Project W-61 study which included data from the U. S. Sheep Experiment Station provided additional information on gross hereditary differences involved in lamb traits as determined by intra-environment breed differences. Twelve percent of the variance in live weight and carcass weight was attributed to breed effects. Live conformation

score, condition score, Federal grade and carcass conformation score showed rather large breed effects which amounted to from 32 to 47% of the intra-environmental variation. Breed differences accounted for approximately 25% of the variation in body length, heart girth, width of chest and depth of chest, and about 12% of the variation in most wholesale cuts, but essentially none of the variation in weight of loin or fat thickness at 12th rib. In general, breeds differed but little in the percent of the various wholesale cuts in the carcass. The intra-breed and environment correlation between Federal grade and live conformation and condition scores was on the order of 0.5. Between Federal grade and slaughter weight the correlation was 0.4. The value of the body measurements, body length and heart girth, for example, in predicting carcass merit, as measured by area of loin eye or combined weight of rack, loin and leg, were of no value when either slaughter or carcass weight was known and held constant. Similarly, live conformation score was of little value in predicting the two carcass measurements indicated. For lambs producing carcasses of the same weight, the ones with shorter bodies and the higher live conformation scores had greater thickness of fat over the 12th rib. Carcass weight accounted for the greatest variation in fat thickness, however. Neither live conformation nor condition score was effective in predicting area of eye muscle or weight of rack, loin and leg when live weight was held constant, nor were they very important when weight was free to vary. Both conformation and condition score appeared to be of some predictive value in estimating fat thickness at the 12th rib in weight constant lambs, with condition score being slightly more important. (AH b6-3C)

5. Factors affecting carcass merit in fed lambs. A study was conducted to determine the effects of various measures of fat content of lamb carcasses on carcass measurements and measures of retail merit of lamb carcasses. It was found that 3-year-old ewes produced lambs with more pounds of high priced cuts, more pounds of retail trimmed meat, and with smaller kidney knob than the other age of dam groups. There was a difference between years in carcass fat content. Also, a ration composed of 70% alfalfa, 20% milo, and 10% molasses resulted in carcasses containing more fat than a pelleted ration of 100% alfalfa. Ram lambs had less trimmable fat than wethers. Single lambs had the smallest loin eye area and twin ram lambs raised with ewe lambs had the largest loin eye area. There was a small breed difference in tenderness and lambs from 2-year-old dams were more tender than lambs from older dams. Four measures of retail merit used were: retail trimmed meat per day of age; retail value per hundred weight of carcass; pounds of retail trimmed meat and pounds of high priced cuts. Highly significant correlations were found among these four measures, and in most instances they were negatively related to the various measures of fat in the carcass. The correlations between these four measures of retail merit and pounds of fat trim were $-.63$, $-.62$, $-.69$, and $-.56$, respectively. Fat thickness over the loin was related to these measures of merit with correlations of $-.33$, $-.35$, $-.32$, and $-.36$, respectively. (AH b1-10, AH b1-11, and AH b1-12)

C. Pork

1. Tenderness and palatability. The degree of marbling in pork loins influences the overall taste panel desirability score of the heated loin roast. A study of loin roasts from 42 pigs of various ages suggests that loins with greater degrees of marbling are more palatable. Marbling scores of 1, 2, 3, and 5 (abundant) received palatability scores of 5.4, 5.6, 6.2, and 6.9, respectively. Among these same pork loins, those pigs that received full feed had palatability scores of 6.1, while loins of the other half of the pigs on a restricted energy ration had palatability scores of 5.1.

Among samples from 205 recurrent selection pigs, the tenderness of loin roasts was greater for the control breed-cross group than for the control line-cross (predominantly Landrace) group. The difference was noted in panel score, Warner-Bratzler shear value, and in tenderness press values. Loins from pigs with half breed-cross and half line-cross breeding averaged less tender than those from either of the parent lines. Although the number of F₁ animals tested was small, the 19 pork loins studied had average tenderness press values of 402 pounds; whereas the parent lines had average values of 317 and 357 pounds. These data suggest possible heterosis in pork tenderness.

Certain cross-sectional variations in tenderness were studied among 97 loin roasts by using a tenderness panel, Warner-Bratzler shear, and the slice tenderness evaluator (STE). The relatively small sampling area required by the STE allowed taking measurements at six locations within a slice of pork loin roast. STE shear values ranged from 4.07 pounds (tender) at a lateral location and 5.04 (slightly tender) at a medial location. Puncture values measured by the STE at a medial location were 40% higher than those at a lateral location. When data were grouped by general location area, the lateral portion of the loin slice was decidedly more tender than either the dorsal or medial portions. (AH a4-3)

A study of palatability and quantity of pork as influenced by breed and fatness indicated that differences due to breed and sex may be a factor to be considered in pork studies. In a study involving 119 Duroc and 111 Yorkshire pigs it was found that loin samples from Duroc pigs had significantly more intramuscular fat, more tender and juicier meat than similar samples from Yorkshire pigs. Barrows had a more desirable flavor of lean than gilts in the Duroc breed, with no difference in other quality factors. In case of the Yorkshires, the flavor of fat was more desirable in barrows than gilts with little difference in other quality factors. All of these pigs were fed to the same final feedlot weight of approximately 225 pounds and were fed the same ration. (AH a4-3)

2. Composition. The chemical analysis has been completed on 97 hogs slaughtered at 50-pound intervals from 75 to 275 pounds. An extensive least squares analysis has been completed on the analyses of ham lean,

carcass lean, ham fat, and carcass fat. There were significant differences between weight groups in percentages of water, protein and ether extract fat for the ham and carcass lean. Gilts had significantly less ether extract fat in the ham lean than barrows. (AH a4-3)

Ultrasonic estimates of average subcutaneous fat thickness at four points were made on 66 pigs of various ages. The right side of each carcass was separated into lean, fat, bone, and skin. A closer relation was noted between the ultrasonic fat measurement and percentages of fat and bone than between the ultrasonic fat measurement and percentages of lean and skin. The effectiveness of ultrasonic fat measurements as an estimator of carcass percentage composition of fat, lean, skin, and bone is given by correlation coefficients of 0.85, -.67, -.70, and 0.83, respectively. These data show that as subcutaneous fat increases, percentages of lean and skin decrease, and percentage of fat and bone increase. (AH a4-3 and MQ 3-34)

3. Carcass evaluation. Studies were continued on ham volume as a method for determining yields of preferred cuts and composition. Volumes of total carcass, loin, and shoulder have also been constructed and are being statistically analyzed for possible use as an index of yield and composition of the live animal. (AH a4-3)

The influence of slaughter weight ranging from 100 to 200 pounds on desirability of cuts was studied with 80 carcasses from Yorkshires and crossbred barrows and gilts. Taste panel scores and cooking losses were not influenced to any marked degree by weight. Loin chops and 7-rib loin roasts from the heaviest pigs were preferred by consumers, while boston butt roasts from the lightest group were preferred. Customers would buy cuts from the lightest group, except 7-rib loin roasts, which were too small. As slaughter weight increased, the percent of primal and lean cuts decreased while carcass length, dressing percentage, and loin-eye area increased. Physical separation of the rough ham showed percent lean decreasing and percent fat increasing as weight increased. (AH al-23)

Muscle development as related to age was studied in 32 pigs. Significant effects due to age were noted for area of muscle fiber, intramuscular fat deposition, iodine number of intramuscular fat, water content, and protein content. Growth curves of the exponential form based on estimate of the mature longissimus dorsi muscle indicated three periods of growth: (1) rapid growth from birth to 80 days, (2) transition from 80 to 120 days, and (3) fattening from 120 days to maturity. (AH al-22)

4. Color. Research on color in pork as influenced by heredity, sex, age, feeding, and management was continued as a PL 480 study with the Institute of Animal Physiology and Nutrition Laboratory of Animal Products, Polish Academy of Science, Warsaw, Poland. The third progress report was divided into three parts -- influence of sample preparation; variation as

influenced by husbandry factors (sex, age, etc.); and metabolic factors. Color in a cross-section slice of fresh muscle tissue varies to such an extent that it is difficult to subjectively or objectively evaluate it. A minced sample technique was developed, and the values obtained transformed into slice values which compare favorably with those values obtained directly from the slice. Variations in color due to husbandry practices was that of comparing the color of lean tissue as found in gilts and barrows. The results of this study show that meat of gilts is characterized in comparison with that of barrows by lower fat content, darker color, and greater concentration of myoglobin and total pigment. Water-holding capacity of meat did not differ significantly. As age and live weight of pigs changed moisture content of lean was lowered, fat content and protein content raised, water-holding capacity less, and myoglobin content increased. Though lightness of color was not changed, dominant wave length and saturation showed clear shifts. Stability of color changed as age and live weight increased. A study of the metabolic factors that may influence color is in progress, with no results to report. (E21-AH-2)

D. Poultry and Eggs

Studies were made of the eggshell weight of eggs with sound and cracked shells. The shells of cracked eggs ranged in weight from 3.5 to 6 grams. Eggs with shells weighing less than 3.5 grams were lost in the laying house due to complete breakage. Eggs having shells weighing more than 6.0 grams were seldom cracked under good handling methods. As the weight of the shell decreased from 6.0 grams to 3.5 grams, the percentage of eggs with cracked shells increased logarithmically, so that the empirical probability of the cracking could be calculated for various shell weights. (AH e4-10)

E. Wool and Fiber

1. Factors affecting quality and value of wool. Investigation of the relationship between quality traits and the economic relations was continued in 1963. Staple length and fiber diameter were determined from measurements of 100 hook staples drawn from each grade lot. Clean fiber and vegetable matter content were determined by the core test. The 64/70's staple fleeces, made up approximately 91.3% of the fine wools, were 1.4 pounds heavier, and had 2.0% higher clean yield than the 64/70's French Combing fleeces. Average staple length of the 64/70's staple fleeces was 0.7 inches longer and the average fiber diameter was 0.4 microns coarser than the 64/70's fleeces classed as French Combing wool. The 64/70's staple wool sold for 62.5 cents a grease pound compared to 56.0 cents for the 64/70's French Combing wool. One lot each of 60/62's and 56/58's staple quality fleeces was studied. The 60/62's staple lot had an average fiber diameter of 23.7 microns, average staple length of 3.3 inches, clean fiber content of 48.47% and sold for 61.5 cents per grease pound. The 56/58's staple lot had an average fiber diameter of 26.4 microns, average staple length of 3.6 inches, clean fiber content of 51.04% and sold for 62.2 cents per grease pound.

The fleeces classed as 54/50's made up a lot of 4,165 pounds which had an average fiber diameter of 29.1 microns, average staple length of 3.8 inches, clean fiber content of 53.84%, and was used for special study of quality traits and mill tests of scourability of branding fluid. Commercial sorting of the 50/54's lot showed a main sort of 98.3% with only 0.7% of a lower grade than 50's. No paint sort was removed. Very little color remained in the scoured wool which did not affect or show up in the top. A top yield of 44.74% was much higher than average yield from territory 50/54's wools. The 46/48's fleeces made up a lot too small to be useful for price comparisons. Crutching and shearing pieces, which made up approximately 0.6 pound per fleece, were scoured with a clean yield of 40.3% and were sold as clean wool for \$1.10 per clean pound. (AH b5-2)

2. Measuring methods to evaluate wool. Investigations on methods of measuring crimp in grease wool staples as an indication of the degree of crimp in a fleece are being continued. A method is in process of being tested, using two rulers at right angles to one another, with one stationary and the other movable. This method gives a more direct reading than does the triangular scale devised in the Beltsville laboratory. Analyses of results have not been completed. However, a method based on the use of the triangular scale is being written for submission as a tentative standard for the American Society for Testing Materials.

Work is progressing at Beltsville, Maryland, on the use of the Digital Fibrograph for measuring length of wool from top. Additional data have been obtained using clamps instead of combs in sample preparation. Results show that either method is satisfactory. The sample is more quickly prepared using the clamps.

The Electronic Fiber Fineness Indicator (EFFI) designed to measure fiber diameter and variability is being tested and evaluated under contract. Revisions have been made in the original circuitry. New developments indicate that further revisions would increase the value of the instrument in measuring more accurately. Study on the techniques of preparing samples for measurement are also being carried out. (AH b5-3C)

3. Relation of fleece traits to processing characteristics. Fourteen grade-breed lots of wool from Dubois, Idaho, each containing 15 mature ewe fleeces visually grading the same spinning count, were studied to investigate further relationships among quality traits of grease wool to processing characteristics, yield and quality of top. Each grade-breed lot was sampled in the grease, scoured at the University of Wyoming Wool Laboratory, and processed into top at Philadelphia College of Textiles and Science. Three years data show that as the fiber diameter of grease wool increases within a breed; staple length, grease fleece weight, and percent clean yield increase; and the number of crimps per inch decreases. Fiber length of the top from each grade-breed lot was approximately 0.11 inch shorter and the average

fiber diameter of the top was 0.55 micron coarser than the grease wool from which it was combed. Variability of both fiber length and diameter in the top increased as the grease wool became coarser. Targhee fleeces were heavier than Columbia fleeces of the same visual grade. Rambouillet fleeces were heavier than Targhee fleeces of the same visual grade. Columbia wool was longer, had fewer crimps per inch, and was coarser than Targhee wool of the same visual grade. Targhee wool was longer, had fewer crimps per inch, and was coarser than Rambouillet wool of the same visual grade. Targhee wool had a slightly higher card yield than Rambouillet or Columbia wool of the same visual grade. (AH b5-7)

F. Humane Slaughter

1. Beltsville, Maryland. The study of physiological stress inflicted upon the hog previous to and during slaughter procedures was completed. The treatments consisted of captive-bolt stunning, electrical stunning, and no preslaughter stunning. The results showed small non-significant decreases in serum protein and in the albumin:globulin ratio when the hogs were immobilized with electricity. A highly significant increase in serum heme concentration occurred in the captive bolt and electrically immobilized groups. Evidence seemed to indicate that the symptoms of physiological stress might be the result of intense extensor muscular spasms associated with preslaughter stunning.

A similar study of the preslaughter and slaughter stresses due to captive-bolt, electrical, and no preslaughter stunning was conducted on lambs. Results showed that the serum heme pigment content was not increased significantly by the preslaughter stunning of sheep. Both the captive-bolt and electrical stunning methods produced a highly significant increase in plasma potassium values and there were small but non-significant decreases for total protein and albumin:globulin ratio in lambs immobilized previous to slaughter.

This project has been discontinued after a six-month extension. (AH j1-2)

2. University of Minnesota. Studies were continued on the complex problem of determining if an animal feels pain upon being immobilized by the use of electrical current. The results of this experiment are being evaluated. (AH j1-3)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Beef

- Alsmeyer, R. H., Hiner, R. L., and Thornton, J. W. 1963. Ultrasonic measurements of fat and muscle thickness of cattle and swine. *Annals N. Y. Acad. Sci.*, 110:23-30, Sept. 26, 1963. (MQ 3-34)
- Bond, James, Hooven, N. W., Thornton, J. W., Hiner, R. L., and Warwick, E. J. 1963. Influence of breed and plane of nutrition on beef production from dairy, dual-purpose, and beef steers. (Symposium on Beef Production from Dairy Cattle, Rome, Italy, August 1963) (AH d3-6 and AH d4-7)
- Hiner, R. L. 1964. Slaughtering, cutting, and processing beef on the farm. *Farmers' Bull.* 1415 (Rev.) (AH d4)
- Hostetler, R. L. and Ritchey, S. J. 1964. Effect of coring method on shear values determined by Warner-Bratzler shear. (Manuscript submitted to *J. Food Tech.*) (AH d4-5c)
- Oltjen, R. R., Davis, R. E., and Hiner, R. L. 1964. Effect of urea, zinc, mineral buffers, stilbestrol, and pellets on the feedlot performance, carcass characteristics and blood proteins of cattle consuming all-concentrate rations based upon ground shelled corn. *J. Animal Sci.* (in press) (AH d4-7)
- Ritchey, S. J. and Hostetler, R. L. 1963. Characterization of the eating quality of four beef muscles from animals of different ages by panel score, shear-force values, extensibility of muscle fibers, and collagen content. (Manuscript submitted to *J. Food Sci.*) (AH d4-5c)
- Thornton, J. W. and Hiner, R. L. 1963. Volume of beef round related to carcass composition. *J. Animal Sci.*, 22(5):829. (Abstract) (Manuscript accepted by Journal) (AH d4-7)
- Warwick, E. J., Davis, R. E., and Hiner, R. L. 1964. Response of monozygotic bovine twins to high and low concentrate rations. *J. Animal Sci.*, 23(1):78-83. (AH d4-7)

Lamb

- Alsmeyer, R. H., Johnson, E. K., Thornton, J. W., and Hiner, R. L. 1963. Relationships among ultrasonic values, live weight, and yields of lamb and beef. (Paper presented at the North Atlantic Section, Am. Soc. of An. Sci. meeting, Morgantown, W. Va., July 1963) (MQ 3-34)
- Mandigo, Roger W. 1963. Factors affecting the retail value of lamb carcasses. M.S. Thesis, New Mexico State University. (AH bl-10, AH bl-11, AH bl-12)

Stanley, M. E., Galgan, M. W., Russell, T. S., Blackwell, R. L., and Orme, L. E. 1963. Variation and correlation of live and carcass traits of lamb. Washington Agri. Exp. Sta. Bull. 649. (AH b6-3C)

Pork

Alsmeyer, R. H., Thornton, J. W., and Hiner, R. L. 1964. Cross-sectional tenderness variations among six locations of pork longissimus dorsi. (Presented at the Institute of Food Technologists meeting, May 1964) J. Food Sci. (in press) (AH a4-3 and MQ 3-34)

Feinstein, Louis and Hiner, R. L. 1963. Anesthesia and its relationship to body composition. Annals N. Y. Acad. Sci., 110:343-348. (MQ 3-34)

Janicki, M. A. and Kolaczyk, S. 1963. Myoglobin and hydration of meat in pigs. Roczniki Nauk Rolniczych Tom, 82-B-4. (E21-AH-2)

Janicki, M. A. 1964. Methodical aspects of objective color measurements in fresh pork meat. (Manuscript prepared - no report as to where published) (E21-AH-2)

Janicki, M. A. 1964. The simplified method of objective color determination in fresh pork meat. (Manuscript prepared - no report as to where published) (E21-AH-2)

Janicki, M. A. 1964. Color and related meat properties in pigs as influenced by sex. (Manuscript prepared - no report as to where published) (PL 480 - E21-AH-2)

Elson, C. E., Fuller, W. A., Kline, E. A., and Hazel, L. N. 1963. Effect of age on the growth of porcine muscle. J. Animal Sci. 22:946-952. (AH a1-22)

Emerson, J. A., Pearson, A. M., Hoefer, J. A., Magee, W. T., and Bratzler, L. J. 1964. Effect of slaughter weight upon processing characteristics, quality, and consumer acceptability of pork carcasses and cuts. J. Animal Sci. 23:436-443. (AH a1-23)

MacLeod, John, Merkel, R. A., and Magee, W. T. 1963. Some linear and area measurements related to muscling in hogs. (Abstr.) J. Animal Sci. 22:1114-1115. (AH a1-23)

Hiner, R. L. and Thornton, J. W. 1964. Carcass length effect on pork yields and composition. J. Animal Sci., 23(4) (AH a4-3)

Hiner, R. L. Improving swine through carcass evaluation. 1963. (Presented at the North Atlantic Section, Am. Soc. of An. Sci. meetings, Morgantown, W. Va., July 1963) (AH a4-3)

Hiner, R. L., Thornton, J. W., and Alsmeyer, R. H. 1964. Palatability and quantity of pork as influenced by breed and fatness. (Presented at the Inst. of Food Technologists meeting, May 1964) Manuscript submitted to J. Food Tech. (AH a4-3)

Kulwich, R., Decker, R. W., and Alsmeyer, R. H. 1963. Use of a slice-tenderness evaluation device with pork. J. Food Tech., 17(3):83-85. (MQ 3-34)

Poultry and Eggs

McNally, E. H. 1964. The relation of eggshell weight to cracked eggs. Poultry Sci. (Abs.) and (in press) (AH e4-10)

Wool and Fiber

Hourihan, M. E., Terrill, C. E., and Harvey, W. R. 1963. Scale for determining crimp of wool staples. J. Anim. Sci. 22(3):819. (Abs.) (AH b5-3)

Hourihan, M. E., Terrill, C. E., and Harvey, W. R. 1963. Use of Fibrograph to measure wool fiber length. J. Anim. Sci. 22(3):819-820. (Abs.) (AH b5-3)

Humane Slaughter

Kitchell, R. L. 1964. Methodological considerations for assessment of pain perception in animals. UFAW Symposium Report, pp. 243-261. (AH j1-3)

Lynch, G. P., Fulmine, F. J., and Hiner, R. L. 1964. Some indications of physiological stress in hogs subjected to various preslaughter treatments. J. Anim. Sci., 23(3):547-550. (AH j1-2)

Lynch, G. P., Fulmine, F. J., and Hiner, R. L. 1964. Some indications of physiological stress in lambs subjected to various preslaughter treatments. J. Anim. Sci., 23(3):661-664. (AH j1-2)

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj.	Incl. in
				Summary of Progress	Area & Sub- Subheading
AH al	Swine Breeding Investigations				
AH al-4*	Improvement of swine through breeding	Ames & Ankeny, Ia.	L. N. Hazel & C. E. Shelby	No	
AH al-6*	Effectiveness of selection for swine carcass quality based on backfat thickness	Columbia, Mo.	J. F. Lasley & L. F. Tribble	No	
AH al-7*	Breeding for improvement of economic traits in swine - purebred and crossbred foundation stocks	North Platte & Lincoln, Nebr.	L. J. Sumption & C. E. Shelby	No	
AH al-8	Selection for combining ability of three lines of swine	Stillwater & Ft. Reno, Okla.	J. A. Whatley, Jr., & C. E. Shelby	Yes	16-A-1 16-B-2,4
AH al-9	Inbreeding, linecrossing, and selection within and between the Hampshire, Duroc and Yorkshire breeds of swine	Brookings, Eureka, & Centerville, S. Dak.	J. W. McCarty & C. E. Shelby	Yes	16-B-1,3
AH al-10	Methods of breeding and selection in swine	Madison, Wisc.	A. B. Chapman & C. E. Shelby	Yes	16-A-1 16-C
AH al-11	Recurrent reciprocal selection for high specific combining ability in crosses between Yorkshire and Montana No. 1 swine	Miles City, Mont.	C. M. Kincaid, H. O. Hetzer, & E. V. Krehbiel	Yes	16-B-2,3
AH al-12	Selection for high and low degrees of fatness in swine	Beltsville, Md.	C. M. Kincaid & H. O. Hetzer	Yes	16-A-1 16-B-1
AH al-13	Reciprocal recurrent selection for general and specific combining ability in two strains of swine	Beltsville, Md.	C. M. Kincaid & H. O. Hetzer	Yes	16-A-1 16-B-2
AH al-14*	Use of rapid inbreeding with selection in evaluating and utilizing potential sources of superior germ plasm	East Lansing, Mich.	W. T. Magee & C. E. Shelby	No	
AH al-16	Effectiveness of selection in pure- bred and crossbred foundation stocks	Urbana, Ill.	H. W. Norton & C. E. Shelby	No	
AH al-17	Selection, inbreeding and crossing for swine improvement	Duluth, Waseca, Morris, Crookston, Grand Rapids, & Rosemount, Minn.	R. E. Comstock, W. E. Rempel, & C. E. Shelby	Yes	16-A-2,3 16-B-2,3
AH al-19	Exploration of metabolic pathways that interrelate biochemical and genetic differences in swine populations	Beltsville, Md.	C. M. Kincaid	Yes	17-A-1 17-B-1,2
AH al-20**	The nature of genetic variability in gene pools of swine	Lincoln, North Platte, & Scotts Bluff, Nebr.	L. J. Sumption & C. E. Shelby	Yes	16-A-1 16-B-5,6 17-A-2
AH al-21**	Effects of selection for low back- fat thickness on various performance traits and carcass desirability in swine	Columbia, Mo.	J. F. Lasley & C. E. Shelby	Yes	16-A-1,3 16-B-1,6 17-A-2
AH al-22*	Genetic relationships between purebred and crossbred swine	Ames & Ankeny, Ia.	L. N. Hazel & C. E. Shelby	Yes	16-A-1 16-B-1,4 21-C-1
AH al-23**	Selection for maximum genetic improvement in swine with a minimum of expenditures	East Lansing, Mich.	W. T. Magee & C. E. Shelby	Yes	16-A-1 16-B-3 21-C-1

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj.	Incl. in
				Summary of Progress	Area & Sub- Subheading
AH a2	Swine Management Investigations				
AH a2-3	Evaluation of new or improved type of hog-rearing equipment	Beltsville, Md.	C. M. Kincaid & J. W. Stevenson	Yes	18-E-1,2,3
AH a2-4*	Evaluation of pasture and harvested forage in swine production	Beltsville, Md.	C. M. Kincaid & J. W. Stevenson	No	
AH a2-5**	The evaluation of management practices as they affect swine production	Beltsville, Md.	C. M. Kincaid & J. W. Stevenson	Yes	18-C
AH a3	Swine Feeding and Nutrition Investiga- tions				
AH a3-12	Trace mineral requirements and biochemical pathways relating to mineral utilization by swine	Beltsville, Md.	I. P. Earle & J. W. Stevenson	Yes	18-D-1,2,3
AH a3-18**	Nutrient metabolism and deposition of specific body tissues by pigs with genetic differences in performance, type, and breed	Beltsville, Md.	R. J. Davey, J. W. Stevenson, & C. M. Kincaid	Yes	18-A
AH a3-19**	To evaluate the nutritive quality and safety of improved cottonseed meals and reexamine methods for improving the safety in feeding of cottonseed meals produced under current commercial processes	Beltsville, Md.	J. W. Stevenson, I. P. Earle, & C. A. Cabell	Yes	18-B
AH a4	Pork Studies				
AH a4-3	Meat characteristics of carcasses of pork developed through breed- ing, nutrition and management	Beltsville, Md.	R. L. Hiner	Yes	21-C-1,2,3
	*Discontinued during reporting year **Initiated during reporting year				

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & Subheading
AH b1	Sheep Breeding Investigations				
AH b1-1	Selective mating and breed comparisons of sheep for farming regions.	Beltsville, Md.	G. M. Sidwell & C. E. Terrill	Yes	13-B-1
AH b1-2	Lamb and wool production from cross-bred sheep from the Hampshire, Shropshire and Southdown breeds.	Beltsville, Md.	G. M. Sidwell & C. E. Terrill	Yes	13-B-1
AH b1-3	Development of a strain of sheep for maximum production of lambs and wool under farm conditions.	Beltsville, Md. Middlebury, Vt.	G. M. Sidwell & C. E. Terrill	Yes	13-B-1
AH b1-4	Selecting and crossbreeding of Merino sheep for increased productivity.	Beltsville, Md.	G. M. Sidwell & C. E. Terrill	Yes	13-B-1
AH b1-5	Investigations of systems of breeding for improvement of range sheep.	Dubois, Idaho	S.K.Ercanbrack & R.L. Blackwell	Yes	13-B-3,4
AH b1-6	Investigations of traits for use in breeding and selection of range sheep.	Dubois, Idaho Bozeman, Mont.	S.K.Ercanbrack & R.L. Blackwell	Yes	13-A-1,2
AH b1-7	Studies in physiology of reproduction of range sheep.	Dubois, Idaho Logan, Utah	C. A. Hulet & R.L. Blackwell	Yes	14-A-1,2, 3,4,5
AH b1-8	Occurrence of estrus in sheep as related to reproductive performance.	Beltsville, Md.	G. M. Sidwell & C. E. Terrill	No	
AH b1-10	Improvement of Navajo sheep by line breeding and selection within the Navajo strain.	Ft. Wingate, New Mexico	S. L. Smith & T. H. Hall	Yes	13-A-3 21-B-2
AH b1-11	Improvement of fine wool sheep under Southwest conditions.	Ft. Wingate, N. M. Univ. Park, N.M.	S. L. Smith, T. H. Hall, E. E. Ray & R. Mandigo	Yes	13-A-3 21-B-2
AH b1-12	Improvement of coarse wool sheep production of wool suitable for Navajo hand weaving.	Ft. Wingate, N.M. Univ. Park, N.M.	L. S. Smith, T. H. Hall, E. E. Ray & R. Mandigo	Yes	13-A-3 21-B-2
AH b1-13	Influence of breeding on efficiency of gains in range sheep.	Dubois, Idaho	K. R. Frederiksen D. A. Price & R. L. Blackwell	No	
AH b1-14	Testing of inbred lines of sheep through top crossing.	Dubois, Idaho Bozeman, Mont.	S.K.Ercanbrack & R. L. Blackwell	Yes	13-B-4
AH b1-15	Investigations of blood group relationships in sheep.	Dubois, Idaho Davis, Calif.	C. L. Stormont & R. L. Blackwell	No	
AH b1-16	Improvement of commercial range sheep through breeding and selection.	LaSal, Utah, Logan, Utah Ft. Collins, Colo. Ft. Wingate, NM Beltsville, Md.	G. M. Sidwell & T. H. Hall	Yes	13-B-5
AH b1-17	Development by selective breeding of a strain of sheep which will reproduce more often than once per year and without seasonal restrictions.	Beltsville, Md.	G. M. Sidwell, C. E. Terrill & I. L. Lindahl	Yes	13-B-2
AH b2	Sheep feeding investigations				
AH b2-1 (d2-31)	The cause and prevention of urinary calculi in fattening beef cattle and sheep.	College Sta., Texas Big Springs, Texas	H.R.Crookshank & I. L. Lindahl	Yes	15-A-1
AH b2-5	Factors in the utilization of pelleted feeds by sheep and other ruminants.	Beltsville, Md.	I. L. Lindahl, P. J. Reynolds & C. E. Terrill	Yes	15-A-2
AH b2-6	Investigations of physiological reactions of sheep and other ruminants in relation to metabolic disorders.	Beltsville, Md.	I. L. Lindahl	No	

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & Subheading
AH b2-7	Investigations on the utilization of forage by sheep.	Beltsville, Md.	I. L. Lindahl & P. J. Reynolds	Yes	15-A-2,3 15-B-1
AH b2-8	Investigations on the nutritive value of new or improved forages.	Beltsville, Md.	I. L. Lindahl & P. J. Reynolds	No	
AH b3	Sheep management investigations				
AH b3-1	Investigations of sheep grazing management on ranges of the Intermountain region.	Dubois, Idaho	D. A. Price, R. D. Humphrey & R. L. Blackwell	No	
AH b3-4	The response of Targhee sheep to different environment.	Hawaii, Dubois, Moscow, Idaho, Ft. Wingate, N.M., Spooner, Wisc., Beltsville, Md.	C. E. Terrill	No	
AH b3-5	The effect of shearing, light and season on rate of wool growth.	Beltsville, Md.	M. E. Hourihan & C. E. Terrill	No	
AH b3-6	Investigation of the causes of lamb mortality and development of methods for reducing it.	Beltsville, Md.	I. L. Lindahl, G. E. Whitmore, C. G. Potts & C. E. Terrill	Yes	15-D-2
AH b3-7	Methods of producing milk fat "spring" lambs.	Ft. Reno, Okla.	J. V. Whiteman, Jr. I. L. Lindahl C. E. Terrill	Yes	13-A-4,5 14-A-2 15-D-1
AH b3-8	Influence of environment at different geographic locations on fleece and body traits of sheep.	Beltsville, Md.	C. E. Terrill	Yes	14-B-1
AH b3-9	Investigation of nutrition and management of range sheep.	Dubois, Idaho	D. D. Price, R. D. Humphrey & R. L. Blackwell	Yes	15-A-2,3 15-B-2
AH b3-10	Comparative productivity of pastures grazed by beef cattle alone, sheep alone and by the two species in combination.	Beltsville, Md.	I. L. Lindahl & P. J. Reynolds	Yes	4-D-1 15-C-1
AH b3-11	Influence of management practices on internal parasitism of lambs.	Beltsville, Md.	I. L. Lindahl & C. E. Terrill	Yes	15-C-2
AH b3-12	Fetal electrocardiograph in livestock	Beltsville, Md.	I. L. Lindahl	Yes	14-A-6
AH b4	Goat nutrition investigations				
AH b4-3	Investigation of dairy goat production.	Beltsville, Md.	I. L. Lindahl & C. E. Terrill	No	
AH b5	Investigations of wool and other animal fibers.				
AH b5-1	Growth and development of the skin, fibers and accessory follicular structures in goats.	Beltsville, Md. McGregor, Texas	L. M. Hansen & E. H. Dolnick	Yes	14-C-1,2, 3
AH b5-2	Factors affecting the quality and value of wool.	Dubois, Idaho. Beltsville, Md.	L. O. Wilson, R. L. Blackwell, M. E. Hourihan & C. E. Terrill	Yes	21-E-1
AH b5-3	Evaluation of wool from farm sheep for breeding, nutrition and management studies.	Beltsville, Md. Knoxville, Tenn.	M. E. Hourihan & C. E. Terrill	Yes	21-E-2
AH b5-5	Influence of age and season on the skin and follicular structures associated with shedding in Angora goats.	Beltsville, Md. McGregor, Texas	L. M. Hansen E. H. Dolnick	Yes	14-C-4
AH b5-6	Investigations of wool for the improvement of Navajo, Navajo crossbred, Targhee and Targhee crossbred sheep under Southwest range conditions.	Ft. Wingate, N.M.	T. H. Hall & S. L. Smith	No	

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

[illegible]

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj.	Incl. In
				Summary of Progress	Area & Subheading
AH d1	Beef and Dual-Purpose Cattle Breeding Investigations.				
AH d1-1 (rev. #2)	Breed crossing for increased production in beef cattle.	Miles City, Mont.	N. M. Kieffer	Yes	2-A-2
AH d1-2 (rev. #2)	Development of superior lines of beef cattle.	Miles City, Mont.	N. M. Kieffer	Yes	2-A-1,3
AH d1-3 (rev.)	The development of more efficient beef cattle for Georgia through the use of selection, progeny testing, inbreeding and crossbreeding.	Tifton, Ga. Reedsville, Ga.	B. L. Southwell W. C. McCormick	No	
AH d1-4 (rev.)	The improvement of beef cattle for Virginia through breeding methods.	Front Royal, Va. Blacksburg, Va.	B. M. Priode K. P. Bovard	Yes	2-A-3 3-A-1
AH d1-5 (rev.)	Selection of cattle adapted to beef production in Southeastern United States.	Brooksville, Fla.	W. C. Burns Marvin Koger	No	
AH d1-6 (rev.)	Selection for changes in meatiness in beef cattle and a study of the response to selection for adaptability in the Gulf Coast area.	Jeanerette, La.	R. S. Temple T. M. DeRouen W. L. Reynolds	No	
AH d1-7 (rev.)	Heterosis from crosses among British breeds of beef cattle	Blacksburg, Va. Steel's Tavern, Va.	T. J. Marlowe- substituting for J. A. Gaines, who is on leave.	Yes	2-A-2 2-B-3 2-C-1
AH d1-8 (rev.)	Evaluation of performance records in beef cattle.	Fayetteville, Ark.	Warren Gifford C. J. Brown	Yes	2-B-1
AH d1-9 (rev.)	The improvement of producing ability of beef cattle.	Knoxville, Tenn.	C. S. Hobbs R. S. Temple	Yes	2-B-1,3 2-C-4
AH d1-10 (rev.)	The improvement of beef cattle through breeding methods.	Ames, Iowa	L. N. Hazel	Yes	2-A-2
AH d1-12 (rev. #2)	Effectiveness of selection for productive efficiency and carcass quality and the importance of heterosis in beef cattle.	Ft. Robinson, Nebr. Lincoln, Nebr.	J. E. Ingalls K. E. Gregory	Yes	2-A-2 2-B-1
AH d1-13 (rev. #2)	The effectiveness of inbreeding selection in the improvement of performance of beef cattle	Brookings, S. Dak.	C. A. Dinkel	Yes	2-C-1,4
AH d1-14 (rev.)	Breeding and selection of beef for the Southwest	Tucson, Ariz. San Carlos, Ariz.	O. F. Pahnish	Yes	2-B-3

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj.	Incl. In
				Summary of Progress	Area & Subheading
AH d1-16 (rev.)	A study of selection, inbreeding, and crossing of inbred lines within the Hereford breed.	Ft. Collins, Colo. Ft. Lewis, Colo.	H. H. Stonaker Kent Riddle	Yes	2-A-3
AH d1-17 (rev.)	Recurrent selection and record of performance selection in open and closed beef cattle herds.	Bozeman, Mont. Havre, Mont.	F. S. Willson	Yes	2-A-1
AH d1-18* (rev.)	Breeding beef cattle for Southwestern ranges.	State College, N. Mex.	L. A. Holland	No	
AH d1-19 (rev.)	The improvement of beef cattle through breeding methods using basic physiological differences in rate and efficiency of gains and carcass evaluation.	Corvallis, Ore.	Ralph Bogart	Yes	2-A-1
AH d1-20 (rev.)	The development of breeding techniques and selection criteria for improvement of economically important characteristics in Hereford and Shorthorn cattle.	Logan, Utah	J. A. Bennett	Yes	2-B-1
AH d1-22 (rev.)	The improvement of production and adaptation of beef cattle within purebreeds and certain of their crosses through breeding methods.	College Station, Tex.	T. C. Cartwright	Yes	2-B-1,3
AH d1-23 (rev.)	Genetic and environmental interactions for performance and carcass traits in beef cattle.	Raleigh, Plymouth, Laurel Springs, and Butner, N. C.	E. U. Dillard	Yes	2-C-3
AH d1-25* (rev.)	Improvement of beef cattle through the application of breeding methods: I. Criteria for improving effectiveness of selection; II. Head form studies; and, III. Immunogenetics of beef cattle.	Laramie, Wyo. Gillette, Wyo.	P. O. Stratton	No.	
AH d1-27 (rev. #2)	Relationships of beef and dairy characters in Milking Shorthorn cattle.	Rosemont, Minn. St. Paul, Minn.	C. L. Cole	No	
AH d1-28 (rev.)	A study to determine the breeding worth of inbred and outbred bulls from various sources	State College, Miss. Prairie, Miss.	J. C. Taylor	No	
AH d1-29 (rev.)	Improvement of beef cattle of Alabama through breeding methods.	Auburn, Ala.	T. B. Patterson	Yes	2-A-2 2-B-3
AH d1-30 (rev.)	Improvement of reproductive performance in beef cattle.	Jeanerette, La. Beltsville, Md.	W. L. Reynolds	Yes	2-A-2 3-A-2
AH d1-31 (rev.)	Effectiveness of selection for productive efficiency and carcass merit and the development of techniques for the identification of dwarfism carriers in beef cattle.	El Reno, Okla. Stillwater, Okla.	D. F. Stephens E. J. Turman	Yes	2-B-1,2,3 2-C-2
AH d1-32 (rev.)	Genetic-environmental influences on production and carcass traits in beef cattle.	Beltsville, Md.	E. J. Warwick	No	

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj.	Incl. In
				Summary of Progress	Area & Subheading
AH dl-33 (rev.)	Increasing reproductive efficiency in range beef cattle.	Miles City, Mont.	R. A. Bellows	Yes	2-A-2 3-A-1,3,4
AH dl-34 (rev.)	Biochemical and cytological investigations of inherited dwarfism in beef cattle.	Gainesville, Fla. Knoxville, Tenn.	Marvin Koger R. S. Temple	Yes	2-C-4
AH dl-35*	A study of dwarfism in beef cattle.	Blacksburg, Va.	T. J. Marlowe	No	
AH dl-36 (rev.)	Interactions between genotype and environment in selection for economically important traits in Hereford cattle.	Reno, Nev., and Branch Stations	C. M. Bailey	Yes	2-A-1
AH dl-37 (rev.)	Improvement of reproductive performance in beef cattle.	Ft. Robinson, Nebr.	J. N. Wiltbank	Yes	2-A-2 3-A-1,2,3,5
AH dl-39	Biological and genetic analyses of normal and mutant stocks in beef cattle with special emphasis on dwarfism.	Davis, Calif.	P. W. Gregory	No	
AH dl-40	Breeding experiments to investigate the nature of genetic improvement in beef cattle productivity with special emphasis on the performance of inbred lines and their crosses.	Davis, Calif.	W. C. Rollins	No	
AH dl-41	A study of response to selection and genetic-environmental interaction in genetically similar groups of Hereford cattle at two locations.	Miles City, Mont. Brooksville, Fla.	E. J. Warwick W. C. Burns	Yes	2-C-3
AH dl-42**	Heterosis in beef cattle.	Spickard, Mo.	J. F. Lasley	No	
AH dl-43**	Genetic and environmental influences on traits of economic value in beef cattle.	Madison, Wisc.	E. R. Hauser	Yes	2-B-3 2-C-1

*Terminated during reporting year.

**Initiated during reporting year.

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. In	
				Summary of Progress	Area & Subheading
AH d2	Beef and Dual Purpose Nutrition Investigations.				
AH d2-3* (rev.)	Evaluation of feeds and forages for beef production in the Coastal Plains region.	Tifton, Ga.	B. L. Southwell	Yes	4-C-1
AH d2-8* (rev.)	Techniques for evaluation of feed intake, digestibility, and utilization of forage by grazing beef cattle and other livestock.	Beltsville, Md. Raleigh, N. C.	P. A. Putnam G. Matrone	Yes	4-A-1,6
AH d2-10 (rev.)	Cause and prevention of cattle losses on wheat and other pastures with special reference to grass tetany.	College Station, Tex.	H. R. Crookshank	No	
AH d2-11 (rev.)	The effect of interrupted growth on the efficiency of beef production.	Beltsville, Md.	P. A. Putnam	Yes	4-A-1
AH d2-12 (rev.)	Growth, development, and reproductive performance of heifers and cows under different winter treatments.	Ft. Reno, Okla.	D. F. Stephens	Yes	3-A-1,5 4-E-1
AH d2-13 (rev.)	Cause and prevention of acute bloat in ruminants.	Beltsville, Md.	J. Gutierrez	Yes	4-A-2
AH d2-14 (rev. #2)	Nutritive value of feeds and forages as influenced by lignin, cellulose, and other feed components.	Beltsville, Md.	P. A. Putnam	Yes	4-A-1 4-B-1 4-C-2
AH d2-21 (rev.)	Management and feeding practices affecting the gains of beef cattle on range and in the feedlot.	Ft. Robinson, Nebr.	J. E. Ingalls	Yes	4-E-1
AH d2-22 (rev.)	Determination of the relation between protein and energy deficiencies and reproduction ability of beef cattle.	Beltsville, Md.	J. Bond	Yes	3-A-1 4-A-1
AH d2-24 (rev.)	The effect of ruminal microorganisms on plant saponins and related compounds.	Beltsville, Md.	J. Gutierrez	No	
AH d2-26 (rev.)	Studies on the nutritional relationships between the ruminal protozoa and bacteria and their contribution to digestion in cattle and other ruminants.	Beltsville, Md.	J. Gutierrez	Yes	4-A-5
AH d2-28	The relation of physical form and roughage content to the feeding value of beef cattle rations.	Beltsville, Md. Front Royal, Va. Ft. Reno, Okla.	P. A. Putnam B. M. Priode D. F. Stephens	Yes	4-B-1 4-C-1,2
AH d2-30	Influence of harvesting factors on the nutritive value of corn and other grains.	Beltsville, Md.	C. A. Cabell	No	

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj.	Incl. In
				Summary of Progress	Area & Subheading
AH d2-31 & AH b2-1 (rev.)	The cause and prevention of urinary calculi in fattening beef cattle and sheep.	College Station, Tex.	H. R. Crookshank	Yes	4-A-3
AH d2-32	Investigations of residues of new pesticides when ingested by beef cattle.	Beltsville, Md. Tifton, Ga.	R. E. Davis B. L. Southwell	Yes	4-A-4
AH d2-34	Evaluation of pastures and forages in the Gulf Coast area in terms of reproductive performance by beef cattle.	Jeanerette, La.	W. L. Reynolds	Yes	3-A-1 4-E-1
AH d2-35	The interaction of nutrition and management in the growth and development of beef cattle.	Newell, N. Dak.	J. A. Minyard	Yes	4-B-1
AH d2-36 (Supersedes AH d2-12 rev.)	Growth, development, and reproductive performance of heifers and cows under different winter feeding treatments.	Ft. Reno, Okla.	D. F. Stephens	Yes	4-E-1
AH d2-37 (Supersedes AH d2-28)	The relation of basic ration components and physical state of feeds to their feeding value.	Beltsville, Md. Ft. Reno, Okla.	P. A. Putnam R. R. Oltjen D. F. Stephens	No	
AH d2-38(c)**	Factors affecting the utilization of corn, milo, barley and wheat in rations of beef cattle.	Davis, Calif.	G. D. Lofgreen	No	
AH d2-39(c)**	A study of relative significance of ruminal and post-ruminal digestion of starch by beef cattle.	Lexington, Ky.	G. E. Mitchell	No	
AH d2-40(c)**	Formulation of supplements to control feed intake of beef cattle.	Gainesville, Fla.	J. F. Hentges, Jr.	No	
AH d2-41(c)**	Endocrine function and energy retention of the post-partum beef female as influenced by pre-partum energy intake.	Lincoln, Nebr.	D. R. Zimmerman	No	
AH d2-42** (Supersedes AH d2-3 rev.)	Nutritive evaluation of forages for beef production in the Coastal Plain region.	Tifton, Ga. Beltsville, Md.	B. L. Southwell R. E. Davis	No	

*Terminated during reporting year.

**Initiated during reporting year.

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. In	
				Summary of Progress	Area & Subheading
AH d3	Beef and Dual Purpose Management Investigations.				
AH d3-1 (rev. #2)	Sustained beef cattle production and maintenance of range quality in the Northern Great Plains by use of supplemental spring pastures	Miles City, Mont.	J. J. Urick	Yes	4-D-1
AH d3-2 (rev.)	Management of pastures and cattle for beef production.	Brooksville, Fla.	W. C. Burns	Yes	4-D-1
AH d3-3 (rev. #2)	Improving herd management on forest range.	Alapaha, Ga.	B. L. Southwell	Yes	4-D-1
AH d3-4 (rev. #2)	Integration of livestock and timber production on intensively managed pastures.	Alapaha, Ga.	B. L. Southwell	Yes	4-D-1
AH d3-6	The comparisons of the production of beef from beef, dual-purpose, and dairy steers.	Beltsville, Md.	J. Bond E. J. Warwick R. E. Davis J. W. Thomas N. W. Hooven R. L. Hiner	Yes	4-E-2 5-A-5 21-A-3b
AH d3-7	Effects of management and growth variables on performance and carcass merit in beef cattle.	Ft. Reno, Okla.	D. F. Stephens	Yes	4-E-1

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. In	
				Summary of Progress	Area & Subheading
AH d4	Beef and Veal Studies				
AH d4-4 (rev.)	Histological characteristics of muscle tissue of beef developed through breeding, nutrition and management.	Beltsville, Md.	R. L. Hiner	Yes	21-A-1
AH d4-5(c) (rev.)	Characterization of attributes affecting tenderness in beef as related to production factors.	Beltsville, Md. College Station, Tex.	R. L. Hiner R. L. Hostetler	Yes	21-A-1
AH d4-6 (rev.)	Biochemical and physical characteristics of beef as affected by production factors.	Beltsville, Md.	R. L. Hiner	Yes	21-A-1
AH d4-7	Meat characteristics of carcasses of beef developed through breeding, nutrition and management.	Beltsville, Md.	R. L. Hiner	Yes	21-A-2, 3a

Line Project Check List -- Reporting Year July 1, 1963, to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & Subheading
AH e1	Poultry breeding investigations				
AH e1-43	Evaluation of breeding systems for chickens.**	Lafayette, Ind. & 11 North Central State Experiment Stations	S. P. Wilson & Cooperators	No	
AH e1-43 (C) (Rev.)	Evaluation of breeding systems for chickens.*	Lafayette, Ind. & 11 North Central State Experiment Stations	S. P. Wilson & Cooperators	Yes	8-B-1, 2
AH e1-44	Development and evaluation of breeding techniques in chickens.	Athens, Ga., & 14 Southern State Experiment Stations	R. E. Cook & Cooperators	Yes	8-A-4, 6 8-B-2
AH e1-45	Genetic and physiologic bases for poultry improvement.**	Twelve North-eastern State Experiment Stations	C. W. Hess & Cooperators	Yes	8-A-5, 6
AH e1-46	Genetic and environmental factors affecting reproduction in turkeys.	Six Western State Experiment Stations	C. W. Hess & Cooperators	Yes	8-A-6
AH e1-47	Avian reproduction under subcircadian periodicities.	Beltsville, Md.	H. L. Marks	Yes	8-A-3
AH e1-48	Genetic aspects of the ability of chickens to utilize amino acids.	Beltsville, Md.	C. W. Hess	Yes	8-A-1
AH e1-49	Genetic aspects of feed utilization in the chicken.	Beltsville, Md.	C. W. Hess	No	
AH e1-50	Breeding chickens for resistance to gonadotropic hormone inhibition.	Athens, Ga.	R. E. Cook	Yes	8-A-5
AH e1-51	Performance of fowl as influenced by physiological traits and pleiotropic genes.*	Twelve North-eastern State Experiment Stations	R. E. Cook & Cooperators	No	
AH e1-52	Biochemical basis for genetic differences in growth rate.	Beltsville, Md.	P. D. Lepore	Yes	8-A-2
AH e2	Poultry nutrition investigations				
AH e2-13	Fat metabolism in poultry.	Beltsville, Md.	H. Menge, C. C. Calvert	Yes	10-A-3 10-B-1
AH e2-14	Feeding systems in poultry.	Beltsville, Md.	R. J. Lillie	Yes	10-C-2
AH e2-15	Effect of high air temperatures on optimum levels of nutrients in diets of chickens.	Glendale, Arizona	B. W. Heywang	Yes	10-A-1
AH e2-16	Protein-amino acid requirements of chickens and turkeys	Beltsville, Md.	R. J. Lillie	No	
AH e2-17	Cottonseed meal in chicken diets.	Glendale, Arizona	B. W. Heywang	Yes	10-C-1
AH e2-18	Mineral requirements of poultry.	Beltsville, Md.	C. A. Denton R. J. Lillie	Yes	10-A-2
AH e3	Poultry physiology investigations				
AH e3-16	Effect of controlled photoperiods on growth and egg production.**	Glendale, Arizona	R. W. Lowe & B. W. Heywang	Yes	9-B-2
AH e3-17	Egg production efficiency of caged and floor-housed pullets.**	Glendale, Arizona	R. W. Lowe & B. W. Heywang	Yes	9-B-3
AH e3-18	Effect of environment and reproduction in turkeys.	Beltsville, Md.	S. J. Marsden & R. M. Fraps	Yes	9-B-1
AH e3-19	Parthenogenesis in avian eggs	Beltsville, Md.	M. W. Olsen, H. K. Poole & R. M. Fraps	Yes	9-A-2

Line Project Check List -- Reporting Year July 1, 1963, to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & Subheading
AH e3-20	The homograft reaction and immunological tolerance in birds.	Beltsville, Md.	H. K. Poole, I. W. Olsen & R. M. Fraps	Yes	9-A-3
AH e3-21	Mechanisms controlling oviposition in birds.	Beltsville, Md.	I. Opel & R. M. Fraps	Yes	9-A-1
AH e3-22	Pituitary-ovarian relationships controlling egg production in the Coturnix quail.	Beltsville, Md.	H. Opel & R. M. Fraps	Yes	8-A-7
AH e4	Poultry meat and egg quality as affected by nutrition, breeding, physiology and other management factors.				
AH e4-9 (Rev.)	Effect of age, sex, breed and management on the physical, chemical, and morphological characteristics of poultry skin.	Beltsville, Md.	E. H. McNally	No	
AH e4-10	Effect of breeding and management of the flock on the chemical and morphological characteristics of the yolk and yolk membrane of chicken eggs.	Beltsville, Md.	E. H. McNally	Yes	21-D
AH e4-11	The effect of hen's age, season, environmental temperature and on-farm holding conditions on egg quality.	Glendale, Ari.	R. W. Lowe	No	
AH e5	National Poultry and Turkey Improvement Plans. (There are no line projects under this Work Project).	Beltsville, Md. in cooperation with 47 Official State Agencies (Alaska, Hawaii and Nevada not included)	S. A. Moore & R. D. Schar	Yes	20-B-1 20-B-2
AH e6	Improvement of viability of poultry.				
AH e6-2 (Rev. #2)	The development and maintenance of inbred lines of chickens showing a wide range of resistance and susceptibility to avian lymphomatosis.	East Lansing, Michigan	L. D. Crittenden	Yes	11-D
AH e6-3 (Rev. #2)	The production and maintenance of susceptible chickens free of lymphomatosis.	East Lansing, Michigan	L. D. Crittenden	Yes	11-A
AH e6-10 (Rev. #2)	A study of the characteristics of the causative agent of visceral lymphomatosis in the chicken.	East Lansing, Michigan	B. R. Burmester	Yes	11-A
AH e6-17 (Rev.)	Studies on the immunity of chickens to visceral lymphomatosis.	East Lansing, Michigan	B. R. Burmester	Yes	11-B
AH e6-20	Identification of cell types found in the lesions and blood of chickens with the different forms of avian leukosis complex.	East Lansing, Michigan & AMS Washington	A. M. Lucas & E. M. Denington	No	
AH e6-21 (C)	Effect of feeding cod liver oil on the occurrence of lymphomatosis in chickens.	East Lansing, Mich. & Univ. of Wisconsin	B. R. Burmester	No	
AH e6-24 (Rev.)	Studies of the chicken tumor viruses <u>in vitro</u> .	East Lansing, Michigan	J. Solomon	Yes	11-A, D
AH e6-27	Studies on the epizootiology of avian lymphomatosis and related neoplasms.	Penna., N. J., Ind., N. C., Michigan	B. R. Burmester	Yes	11-C
AH e6-28	A study of the genetic variability remaining in highly inbred lines of chickens.	East Lansing, Michigan	L. D. Crittenden	Yes	11-D
AH e6-29	A study of genetic resistance to virus induced neoplasms of chickens.	Ga., Conn., Ind., Calif., Michigan	L. D. Crittenden	Yes	11-D

Line Project Check List -- Reporting Year July 1, 1963, to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & Subheading
AH e7	Relation of environment and management to disease and broiler condemnations.				
AH e7-1	Factors influencing airsacculitis and condemnations in broilers.	State College, Mississippi	R. T. Parkhurst	Yes	12-B
AH e8	Avian anatomy investigations.				
AH e8-1	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Michigan	A. M. Lucas	Yes	1-B-1
* Initiated during reporting year. ** Discontinued during reporting year.					

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & Subheading
AH f1	Fur animal breeding (including rabbits)				
AH f1-1	Genetic investigations of traits for use in breeding and selection for improvement of meat rabbits.	Fontana, Calif. Davis, Calif.	R. B. Casady	Yes	19-A-1,2, 3,4 19-B-1
AH f1-2	Genetics of mink and marten with emphasis on mutant characters and pelt quality.	Madison,Wisc.	R. M. Shackelford	No	
AH f1-3	Development of a superior strain of blue foxes.	Petersburg, Alaska	J. R. Leekley	Yes	19-B-4
AH f1-4	Marten mating systems to increase breeding regularity and prolificacy.	Petersburg, Alaska	J. R. Leekley	Yes	19-B-5
AH f1-6	Effect of breeding does at various intervals following kindling on the growth and weaning weight of the young and on reproductive performance of the doe.	Fontana, Calif. Beltsville,Md.	R. B. Casady	Yes	19-B-3
AH f1-7	Investigations of spontaneous glaucoma.	Fontana,Calif. Los Angeles, Calif.	R. B. Casady	No	
AH f2	Fur animal physiology of reproduction				
AH f2-1	Effect of hormones on growth and reproduction of mink.	Swarthmore,Pa.	R. K. Enders	No	
AH f2-3	Management factors affecting reproductive performance in mink.	Ithaca,New York	H. F. Travis	No	
AH f2-4	A study of lactation in the mink.	Swarthmore,Pa.	R. K. Enders	No	
AH f2-5	Investigation of fetal development and fetal anomalies in rabbits.	Fontana,Calif.	R. B. Casady	Yes	19-B-2
AH f3	Fur animal feeding and nutrition				
AH f3-1	Development of diets based on sea fish and sea mammals and their products for blue fox, mink and marten.	Petersburg, Alaska	J. R. Leekley & C. A. Cabell	Yes	19-C-1,2, 3
AH f3-2	Relationship of nutrient factors and physical characteristics in diet to rabbit production.	Fontana, Calif.	R. B. Casady	Yes	19-C-4
AH f3-4	Study of various proteins as rabbit feed.	Fontana, Calif. Beltsville, Md.	R. B. Casady	Yes	19-C-5
AH f3-5	Investigations of the basic nutrient requirements and nutrient utilization by mink.	Ithaca, NewYork	H. F. Travis	Yes	19-C-6,7
AH f3-6	The development of practical diets and feeding practices for mink.	Ithaca,NewYork	H. F. Travis	Yes	19-C-8,9
AH f3-7	Investigation of hydrocephalus in vitamin A deficient rabbits.	Fontana,Calif. Los Angeles, Calif.	R. B. Casady	No	
AH f4	Fur fiber and fur investigations				
AH f4-3	The priming process in fur bearing animals.	Beltsville,Md.	E. H. Dolnick	Yes	19-B-6,7
AH f4-4	Influence of endocrine factors on the development of fur-bearing animals.	Beltsville,Md.	E. H. Dolnick	No	

Line Project Check List -- Reporting Year July 1, 1963, to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & sub-heading
AH g1	Genetics and interrelations of anatomical and physiological characteristics of dairy cattle.				
AH g1-1	Genetic and phenotypic relation of body form in the growing heifer to body form and producing capacity in the cow.	Beltsville, Md. Urbana, Ill. Columbus, Ohio Lafayette, Ind. St. Paul, Minn.	R. D. Plowman C. A. Matthews	No	
AH g1-2	Genetic and phenotypic interrelationships between body form, internal anatomy and milk production in the cow.	Beltsville, Md.	R. D. Plowman C. A. Matthews	Yes	5-A-4
AH g1-3	Studies of the rate and form of mammary gland development in cattle at different ages, in relation to milk production.	Beltsville, Md. St. Paul, Minn. Huntley, Mont. Columbus, Ohio Lewisburg, Tenn. Madison, Wisc.	R. D. Plowman C. A. Matthews	No	
AH g1-4	Studies of the genetics of feed utilization in dairy cattle	Beltsville, Md. Ithaca, N.Y. Lewisburg, Tenn. Jackson, Tenn. Huntley, Mont. Bozeman, Mont. Logan, Utah	N. W. Hooven, Jr. G. W. Trimmerger J. Owen B. Hazelwood D. Kopland J. Boyd R. Lamb	Yes	5-A-1 5-A-2 5-A-3
AH g1-5	Studies of the genetics of milk constituents and other properties related to milk production.	Beltsville, Md. East Lansing, Mich. Madison, Wisc.	C. A. Kiddy	Yes	5-A-7
AH g1-6	A study involving the repeatability and standardization of blood typing in dairy cattle.	Beltsville, Md. and cooperating laboratories.	C. A. Kiddy R. D. Plowman	Yes	5-A-6
AH g1-7	The importance of immunogenetic factors in problems of lowered fertility in cattle.	Beltsville, Md.	C. A. Kiddy H. W. Hawk	Yes	6-A-4
AH g1-8	Antibodies in bovine milk.	Beltsville, Md.	C. A. Kiddy R. D. Plowman W. D. Schultze	No	
AH g1-28	Relationships of beef and dairy characteristics in Milking Shorthorn cattle.*	St. Paul, Minn. Waseca, Minn.	C. L. Cole W. F. Aunan R. D. Plowman E. J. Warwick	No	
AH g2	The application of advanced genetic concepts and principles for the improvement of dairy cattle.				
AH g2-5	Developing and evaluating desirable production characteristics in Holstein cattle by inbreeding, out-breeding and inter-line crossing.	Lake Mills, Wisc. Madison, Wisc.	W. J. Tyler R. D. Plowman	Yes	5-B-1
AH g2-22	Studies to estimate the relative importance of general and specific combining ability in relation to breeding dairy cattle.	St. Paul, Minn. Columbus, Ohio	R. D. Plowman C. W. Young T. M. Ludwick	Yes	5-B-2
AH g2-23	Evaluation of interbreed matings as a genetic method for improving economically important traits in dairy cattle.	Beltsville, Md. Urbana, Ill. Lafayette, Ind.	R. E. McDowell R. W. Touchberry T. G. Martin	Yes	5-B-5
AH g2-24	The influence of parental relationship on the genetic merit of dairy sires and cows.	Beltsville, Md.	R. D. Plowman	Yes	5-B-3
AH g2-25	The value of the continuous use of progeny tested sires and sons of progeny tested sires for improving dairy cattle.	Beltsville, Md.	R. D. Plowman	No	
AH g2-26	Comparisons of genetic methods of using sires available in artificial breeding of dairy cattle.	St. Paul, Minn.	C. W. Young	Yes	5-B-4

*Initiated during reporting year.

Line Project Check List -- Reporting Year July 1, 1963, to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in		
				Summary of Progress	Area & sub- heading	
AH g2-27	A comparison of selection for milk production with selection for total fat production in dairy cattle.	Cortland, N.Y.	G. W. Trimberger C. R. Henderson	No		
AH g3	Investigations of dairy herd management.					
AH g3-8	Evaluation of management practices for the control of bovine mastitis.	Beltsville, Md.	W. D. Schultze	Yes	7-D-1 6-B-2	
AH g3-10	Electrically controlled and operated equipment for reduction of labor in dairy production.	Beltsville, Md.	R. D. Plowman	No	7-D-2	
AH g3-12	Evaluation and development of equipment and physical methods for control of flies and other dairy cattle pests.	Beltsville, Md.	R. D. Plowman	Yes	7-D-3	
AH g4						
AH g4-1	Relationship of anatomical and physiological characteristics to dairy cattle adaptability.	Baton Rouge, La Tifton, Ga.	A. J. Guidry J. C. Johnson	Yes No	6-C-4	
AH g4-2	Genetic methods for developing adaptability.	Beltsville, Md.	R. E. McDowell	Yes	6-C(1-3)	
		College Sta., Tex.	M. A. Brown	No		
		Baton Rouge, La.	C. Branton	Yes	5-B-6	
		Jeanerette, La.	B. Hollon	Yes	5-B-6	
		Reidsville, Ga.	J. C. Johnson	No		
		Tifton, Ga.	J. C. Johnson	No		
AH g4-3	Influence of management practices and other environmental factors on adaptability of dairy cattle to hot and humid regions	Tifton, Ga.	J. C. Johnson	Yes	7-D-4	
AH g5	Evaluation of concepts for procurement, interpretation and use of dairy herd records	Baton Rouge, La.	A. J. Guidry	No		
		Jeanerette, La.	B. Hollon	No		
AH g5-1	Studies on methods for minimizing environmental influences on production records of individual cows and progeny records.	Madison, Wisc. Beltsville, Md. College Pk., Md.	E. L. Corley	No		
AH h1	The nutritionla factors affecting normal growth and health of calves and growing cattle.					
AH h1-1	Wilted alfalfa silage as a forage for growing dairy heifers	Beltsville, Md.	D. R. Waldo M. Okamoto R. W. Miller	Yes	7-C-1,2	
AH h2	A study of nutritional and related factors affecting the usefulness of producing dairy cattle.					
AH h2-3	Microbiology of the bovine rumen	Beltsville, Md.	M. P. Bryant	Yes	1-D-1,2, 3	
AH h2-5	Factors involved in the efficiency of forage utilization by dairy heifers	Beltsville, Md.	D. R. Waldo	No		
AH h2-6	Development and use of chemical methods for determining the nutritive values of dairy feeds and forages.	Beltsville, Md.	G. F. Fries P. J. Van Soest	Yes	7-A-2	
AH h2-7	The measurement of heat production of grazing cattle.	Beltsville, Md.	D. R. Waldo W. P. Flatt	No		
AH h2-8	Determination of the nutritive value of cattle feeds by calorimetric methods.	Beltsville, Md.	W. P. Flatt C. E. Coppock	Yes	7-A-1	
AH h2-9*	Extent to which agricultural chemicals are secreted into milk.	Beltsville, Md.	J. C. Derbyshire	Yes	7-A-3	
AH h2-10 (C)	Study of the metabolism and excretion of ingested radionuclides in relation to nutrition and health of farm animals and to the accumulation of radionuclides in animal food products.	Tifton, Ga.	B. L. Southwell	No		
		Ithaca, N.Y.	G. F. Fries			
AH h2-11*	A study of the efficiency of use of metabolizable energy for growth of dairy cattle.	Beltsville, Md.	E. A. Kane	No		

*Initiated during reporting year.

Line Project Check List -- Reporting Year July 1, 1963, to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & sub- heading
AH h2-13* (C)	Effects of liberal concentrate feeding on health, reproductive efficiency, milk production, economy of milk production and other related responses.	Ithaca, N.Y.	J. K. Loosli L. A. Moore	No	
AH h3	Studies on the management, preservation and utilization of grassland crops for dairy cattle.				
AH h3-1	A biochemical study of the ensiling of forage crops	Beltsville, Md.	W. C. Jacobson	Yes	7-B-5
AH h3-3	A study of the effects of kinds of crop, kinds of treatment, methods of handling and conditions of storage of forage on the resulting silages and the production of silages suitable for fundamental bacteriological and biochemical studies.	Beltsville, Md.	C. H. Gordon	Yes	7-B-1,2, 3,4,6,7
AH h3-12	Investigation of factors affecting forage production of Tennessee grasslands for dairy cattle.	Lewisburg, Tenn.	D. R. Waldo	Yes	7-B-8,9
AH h3-17	The relation of date of cutting and dry matter content when cut to digestibility, consumption and acre nutrient yields of forage crops.	Huntley, Mont.	D. R. Waldo G. F. Fries	No	
AH h3-18	The effect of varying stocking rates on nutrient yields per acre of orchardgrass-ladino clover pastures and on production per animal of dairy cows grazing these pastures.	Beltsville, Md.	C. H. Gordon J. C. Derbyshire	No	
AH h3-19*	Concentrate supplementation responses of dairy cows on pasture and dry lot conditions.	Logan, Utah Beltsville, Md.	M. J. Anderson D. R. Waldo	No	
AH h3-20* (C)	The effects of variety, selection, and production methods of corn on the cost and feeding value of corn silage for dairy cattle.	College Pk., Md. Beltsville, Md.	C. H. Gordon	No	
AH h4	Bioassay of nutritional requirements and processes of dairy cattle.				
AH h4-1	Unidentified nutrients in milk, milk products and related foods and feeds.	Beltsville, Md.	A. M. Hartman L. P. Dryden	Yes	1-C-2
AH h4-3	The metabolic function of vitamin B ₁₂ .	Beltsville, Md.	A. M. Hartman L. P. Dryden	Yes	1-C-1
AH h4-4	Production of vitamin B ₁₂ by micro-organisms of the bovine rumen.	Beltsville, Md.	A. M. Hartman L. P. Dryden		
AH h5	Physiological studies of reproduction, mammary gland growth and lactation in dairy cattle.				
AH h5-1	Hormonal and nutritional aspects of mammary growth and lactation.	Beltsville, Md.	J. Bitman T. R. Wrenn	Yes	6-B-1 1-B-4
AH h5-2	Development of methods for the determination of secretion rate and metabolism of hormones in dairy cattle.	Beltsville, Md.	J. Bitman	No	
AH h5-3	Physiological mechanisms related to reproductive performance of dairy cattle.	Ithaca, N.Y.	J. Bitman H. W. Hawk W. Hansel	Yes	6-A-1
AH h5-4	Pre- and post-ovulatory factors affecting fertilization and embryonic survival in dairy cattle.	Amherst, Mass.	H. W. Hawk D. L. Black	Yes	6-A-1 6-A-2

*Initiated during reporting year.

Line Project Check List -- Reporting Year July 1, 1963, to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. in	
				Summary of Progress	Area & sub- heading
AH h5-6	Physiological basis for variations in fertilization success and embryo survival that may be associated with lowered fertility in dairy cattle.	Madison, Wisc.	H. W. Hawk J. Bitman L. E. Casida	Yes	6-A-1
AH h5-8	Endocrine influences on embryonic mortality and uterine physiology.	Beltsville, Md.	H. W. Hawk J. Bitman	Yes	6-A-3 1-B-2,3
AH i4	Dairy herd improvement research through analyses of data collected in National Cooperative Dairy Herd Improvement and Sire-Proving Programs and the development of effective production testing organizations.	Beltsville, Md. New Orleans, La. Arlington, Va.	E. L. Corley	No	20
AH i4-1	Research on the evaluation of superior sires and cows in the national dairy herd and on the factors affecting these estimations.	Beltsville, Md. New Orleans, La. Arlington, Va. Bethesda, Md.	E. L. Corley R. H. Miller	Yes	20
AH i4-2	Analysis of different types of records of performance and breeding society organizations, testing plans, methods and forms used in collecting and evaluating production records to improve the effectiveness of DHIA sire-proving and related programs.	Beltsville, Md. New Orleans, La. Arlington, Va. Bethesda, Md.	E. L. Corley R. H. Miller	Yes	20
AH i4-3	Analysis of DHIA cow and herd production records to determine from year to year the relationships between yield, feed inputs, costs and related factors.	Beltsville, Md. New Orleans, La. Arlington, Va.	E. L. Corley J. King R. H. Miller	Yes	20
AH j1	Humane Slaughter of Meat Animals				
AH j1-2*	Humane slaughtering techniques as they influence procedures and quality of meat.	Beltsville, Md.	R. L. Hiner	Yes	21-F-1
AH j1-3*	Electrical stunning as a method of inducing anesthesia in humane slaughtering of meat producing animals.	St. Paul, Minn. Beltsville, Md.	R. L. Kitchell R. L. Hiner	Yes	21-F-2
AH P-1	Pioneering laboratories Pioneering Blood Antigen Laboratory	Beltsville, Md.	S. L. Scheinberg	Yes	1-A-2a, b,c,d
AH P-2	Pioneering Research Laboratory in Basic Animal Genetics	Lafayette, Ind.	Wendell H. Kyle	Yes	1-A-1a, b
MQ 3-34	Projects delegated to AH by AMS Basic research on quality evaluation and development of objective measurement of quality factors in agricultural products.	Beltsville, Md.	Karl Hoke R. L. Hiner	Yes	21-A-1, 2 21-B-2 21-C-2

*Discontinued during reporting year.

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj.	Incl. in
				Summary of Progress	Area & Subheading
A7 AH-1	PL 480 projects Physiology and genetics of characteristics influencing the adaptability of cattle and buffalo for dairy production in India; genetic methods for developing adaptability and the effect of climatic elements and other environmental influences on adaptability.	Izatnagar, India	S. Guha	Yes	6-C-5
A7 AH-6	Nutritional physiology of different breeds of Indian cattle.	Karnal, India	S. W. Ray	No	
A7 AH-11	Factors affecting the utilization of low-grade roughages and production of volatile fatty acids in the rumen of cattle.	Punjab, India	G. S. Sidhu L. A. Moore	No	
A7 AH-21	Evaluation of feedstuffs available in India for protein quality and energy value. *	Ludhiana, India	G. S. Sighu	No	
A10 AH-2	Comparative studies of 'repeat breeders' and normal cows and heifers. *	Beit Dagan, Israel	Nathan Ayalon	No	
A10 AH-3	The mechanism of lactation and its augmentation by hypothalamic stimulation.	Jerusalem, Israel	F. G. Sulman J. Bitman	Yes	6-B-3
A10 AH-7	Utilization and function of vitamin A in nutrition of poultry.	Jerusalem, Israel	A. Bondi	Yes	10-B-2
A10 AH-9	The effect of X-rays on viability genes with special reference to their action in heterozygotes and to the mechanism of heterosis. *	Jerusalem, Israel	Raphael Falk	No	
A10 AH-12	The separation of young and old spermatozoa.	Rehovot, Israel	R. Volcani	No	
A10 AH-13	Factors acting in long-term storage of sperm <u>in vivo</u> .	Rehovot, Israel	R. Volcani H. Schindler	No	
A22 AH-2	White muscle disease of lambs in Turkey	Ankara, Turkey	Cahit Ozcan	Yes	15-A-1
E8 AH-1	Breed differences regarding the antigenic properties of cattle blood, their inheritance in relation to economic characteristics and genetic origin of the breed.	Tikkurila, Finland	Viljo Vainikainen	Yes	5-A-6
E21 AH-1	Secretion of anterior pituitary hormones and ovulation in small ruminants.	Jablonna, Poland	E. Domanski J. Bitman	Yes	1-B-5
E21 AH-2	Color in pork as influenced by heredity, sex, age, feeding and management of animals.	Warsaw, Poland	M. A. Janicki	Yes	21-C-3

Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Summary of Progress	Incl. in Area & Subheading
E21 AH-4	Investigations of blood groups in a new racial group of the "Zlotnicka Pig."	Poznan, Poland	Antonio Kaczmarek	No	
E21 AH-5	Protein compounds of vitamin B ₁₂ and its analogs.	Poznan, Poland	J. Janicki	No	
E21 AH-6	Trace element contents in forage crops in relation to the stage of development of the plants, method of gathering and storage.	Poznan, Poland	K. Gawecki	Yes	4-E-1
E21 AH-7	The reactions in the guinea pig liver microsomes during the protein biosynthesis <u>in vitro</u> . *	Warsaw, Poland	J. Heller P. Szafranski	No	
E25 AH-4	Contribution to the study of metabolism of zinc in living organisms by means of zinc 65.	Madrid, Spain	Carmen Garcia	No	
E25 AH-6	A pilot study with Tribolium of the influence of environmental stress on genetic parameters and response to selection. *	Madrid Spain	Fernando Orozco	No	
F4 AH-1	Improving and evaluating Fayoumi and Dandarawi fowls.	Dekki, Giza, Egypt	I. F. Sayed	No	
S3 AH-7	Structural and physiological characteristics associated with adaptability of cattle in tropical and sub-tropical areas.	Pirassununga, Brazil	J. S. Veiga	Yes	6-C-6
S5 AH-1	Evaluation of the native breed, Costeno con Cuernos, and European breeds and European-native breed crosses when managed and selected for dairy cattle traits under the hot and humid conditions of Northern Colombia.	Turipana, Colombia	R. K. Waugh	No	
S9 AH-1	The nutritional value of the fish silage produced by yeasts fermentation for animal feeding.	Montevideo, Uruguay	Victor H. Bertullo	Yes	1-E

* Initiated during reporting year.



